VOL. XXXIV. — No. 1. JANUARY 1957.

Monthly Bulletin of the International Railway Congress Association

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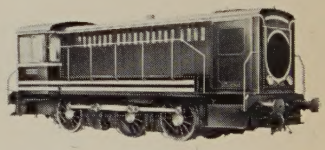

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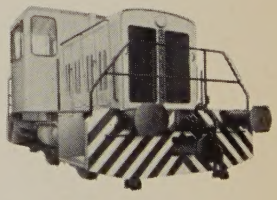

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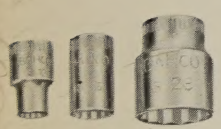

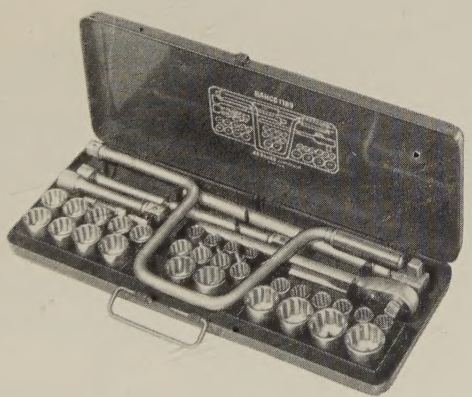

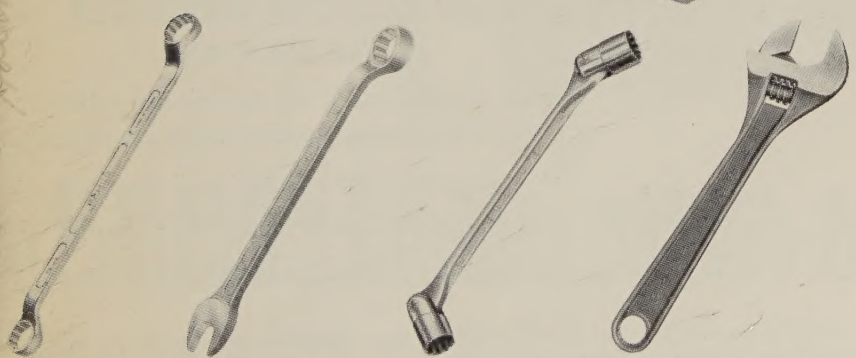

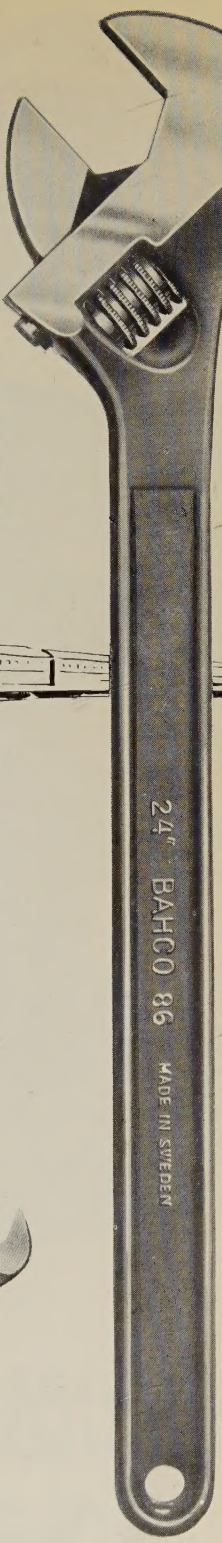

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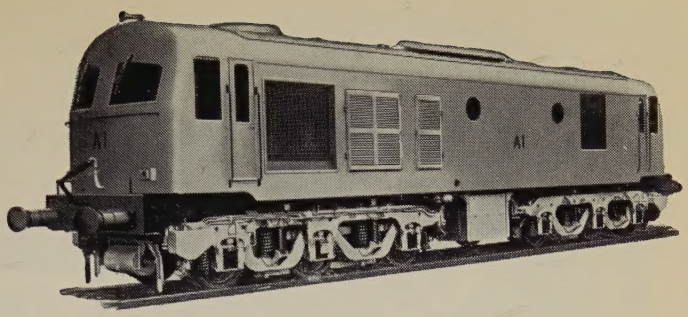

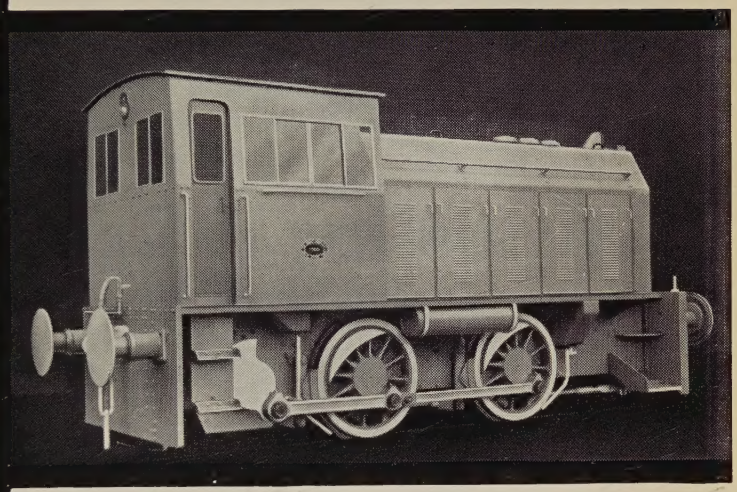

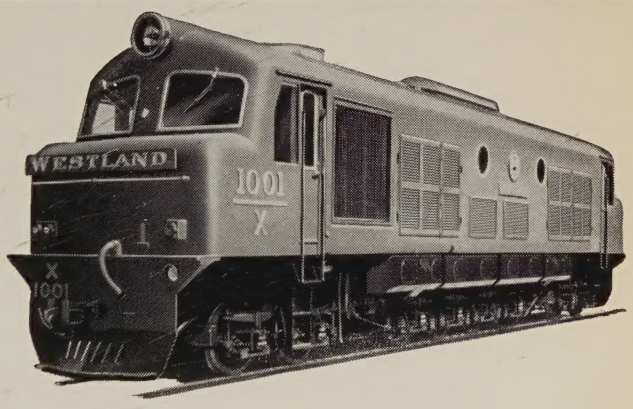

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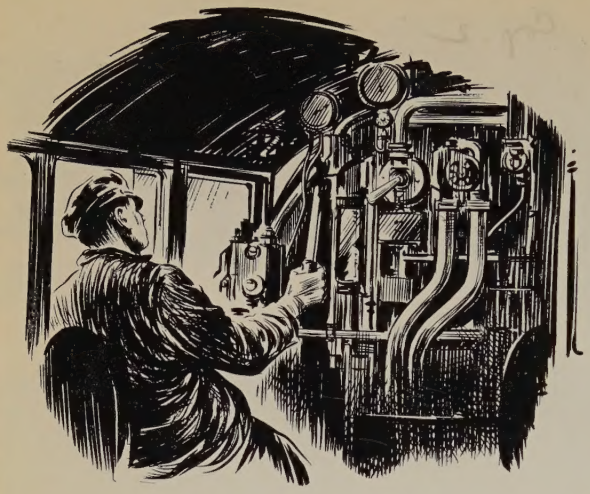

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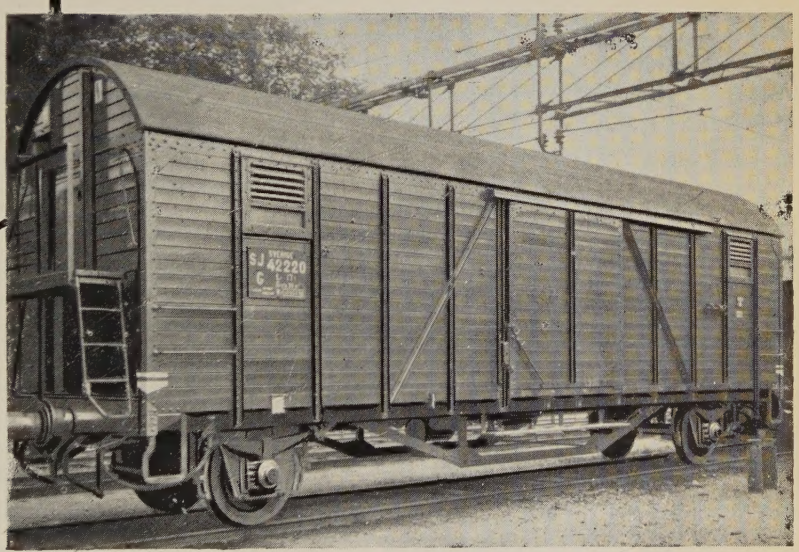

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Alphabetical Index of Advertisers

Firms :		Specialities :
ASEA	—	Railway electrification.
BAHCO (AB)	III	Tools.
Belgian National Railways	—	Electrification.
Belships Company Limited	—	World-wide heavy-lift service.
British Timken Ltd	—	Tapered-roller-bearing axleboxes.
Brugeoise & Nivelles (S. A. La)	—	Railway rolling stock.
Cockerill-Ougrée (S.A.)	II	Machinery and metal structures. Diesel-electric locomotives.
Crossley Brothers Ltd.	V	Diesel locomotives.
De Dietrich & Co.	—	Railway rolling stock.
English Electric Company Ltd (The)	—	Railway electrification.
Ericssons (LM) Signalaktiebolag	—	Railway signalling.
General Electric Company Ltd of England	—	Electrical traction equipment.
Hasler (A.G.)	—	Speed indicators and recorders.
Heemaf (N.V.)	—	Electric motors, generators and apparatus.
Kretz Company	VI	Ultrasonic testing of waggon axles.
Lesjöfors, A. B.	—	Rail fastenings.
Matisa Equipment Limited	—	Permanent way equipment.
Metalexport	—	Railway rolling stock.
Metropolitan-Cammell Carriage & Wagon C°. Ltd.	IV	Lightweight railway coaches.
Metropolitan-Vickers-GRS Ltd.	—	Signalling equipment for railways.
Pressed Steel Co Ltd.	—	Wagons.
R. I. V. (Officine di Villar Perosa)	—	Axleboxes.
S.A.B. (Svenska Aktiebolaget Bromsregulator)	—	Automatic slack adjusters.
Sécheron (S.A. des Ateliers de)	—	Locomotives; motorcoaches.
Shell Company	—	Lubricating oils.
Siemens and General Electric Railway Signal Co. Ltd.	—	Signalling equipment.
S.K.F. (Société Belge des Roulements à Billes)	VII	Axleboxes.
Sulzer Brothers Ltd.	—	Diesel locomotives and railcars.
Superheater Company (The)	VI	Superheaters for locomotives.
Swiss Car and Elevator Manufacturing Corp. Ltd.	—	Railway rolling stock.
United Steel Companies, Ltd. (The)	—	Railway materials.
Vapor International Corporation, Ltd.	—	Heaters for Diesel engines.
Voith, J.M. (G. m. b. H.)	—	Turbo-transmissions.
Westinghouse Brake & Signal Co., Ltd.	I	Railway signalling. Brakes.

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR JANUARY 1957.

1957 **656** .24
Bull. of the Int. Ry. Congr. Ass., No 1, January, p. 1
PENTIGA (K.J.). — **How the Economic Commercial Department of the Netherlands Railways deals with the protection of goods during transport.** (1 200 words & figs.)

1957 **621** .132 .8 (43)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 9.
WITTE (F.). — **Class 50 locomotive No. 1 412 with Franco-Crosti boiler.** (8 500 words, table & figs.)

1957 **656** .257
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 26.
SCHMITZ (W.). — **Thoughts on the automatic routing of trains.** (4 800 words & figs.)

1957 **625** .13 (44)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 38.
MAURY (M.) and CARPENTIER (M.). — **The reconstruction of La Voulte viaduct.** (5 200 words & figs.)

1957 **656** . 2 (73)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 54.
« **Railvan** » **marries road and rail.** (1 800 words, table & figs.)

1957 **624** .5 (73)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 60.
All-welded underline bridge. (800 words & figs.)

1957 **621** .431 .72
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 62.
Framing of a locomotive body. (1 600 words & figs.)

1957 **621** .32 (44)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 67.
VARROY (M.). — **The standard electric handlamps of the French National Railways.** (2 400 words & figs.)

1957 **621** .431 .72 (42)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 74.
Two-car sets commissioned by B. R. (2 800 words & figs.)

1957 **625** .232 (494)
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 80.
GUIGNARD (R.). — **New light weight second class coaches.** (1 600 words & figs.)

1957 **625** .212
Bull. of the Int. Ry. Congr. Ass., No. 1, January, p. 85.
LEITENBERGER (W.). — **Electro-acoustic equipment for detecting flats on the wheels of freight wagons.** (1 600 words & figs.)

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

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Advertisements : All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels.**

CONTENTS OF THE NUMBER FOR JANUARY 1957.

CONTENTS	Page.
I. **How the Economic Commercial Department of the Netherlands Railways deals with the protection of goods during transport,** by K. J. PENTIGA	1
II. **Class 50 locomotive No. 1 412 with Franco-Crosti boiler,** by Dipl.-Eng. F. WITTE	9
III. **Thoughts on the automatic routing of trains,** by Dr.-Eng. Pr. W. SCHMITZ . . .	26
IV. **The reconstruction of La Voulte viaduct,** by M. MAURY and M. CARPENTIER . . .	38
V. **« Railvan » marries road and rail**	54
VI. **All-welded underline bridge**	60
VII. **Framing of a locomotive body**	62

CONTENTS *(continued)*. Page.

VIII. **The standard electric handlamps of the French National Railways,** by M. VARROY . . . 67

IX. **Two-car sets commissioned by B. R.** 74

X. **New light weight second class coaches,** by R. GUIGNARD 80

XI. **Electro-acoustic equipment for detecting flats on the wheels of freight wagons,** by W. LEITENBERGER 85

XII. MONTHLY BIBLIOGRAPHY OF RAILWAYS 1

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Vol. XXXIV. — No. 1. January 1957.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .24]

How the Economic Commercial Department of the Netherlands Railways deals with the protection of goods during transport,

by K.J. Pentinga, Utrecht.

About six years ago the Economic Commercial Department of the Netherlands Railways, carrying out an enquiry into damage caused during transport, borrowed a shock recorder from the Dutch Packings Laboratory at Delft.

Until then, the opinion had always been held that excessive shocks during shunting were the cause of damage, but there was no way of finding out who was responsible. The shock recorder, as is known, is an instrument which records on a wax band together with the times the intensity of shocks suffered by packings during shunting. By means of this instrument fitted as part of the wagon, it is possible to determine the times at which excessive shocks occurred during shunting (in Holland, we consider as excessive shocks during shunting those which occur when two wagons hit each other at more than 5 km (3 miles)/h).

Our first experiments gave remarkable results : although the instrument recorded with the greatest accuracy, it did not record any excessive shocks during shunting, and yet the load had shifted and been damaged. Nor was the packing responsible for the damage as this was examined and passed by the Packing Laboratory at Delft. It was found that damage which till then had been blamed on faulty shunting in the yards was due in actual fact to faulty loading of the goods.

As a result the Railways had to pay damages in many cases. This does not mean to say that there never were any excessive shocks during shunting or that the quality of the packings accepted by the railway are never to blame, but this state of affairs brought out three factors given below, which affect, the arrival of goods at their destination in good condition.

The Netherlands Railways have perfected a method of examination, from which new points of view are constantly being brought out.

By means of the shock recorder, it was found that :

1) a fairly high percentage of the damage was attributable to excessive shocks

Photograph 1. — Before the buffers meet.

Photograph 2. — After the buffers have met.
The liquid is spurting out of the tank wagon.

during shunting (see photos 1, 2 and 3);

2) many cases of damage are due to faulty loading (see photos 4, 5 and 6);

3) finally in many cases, the packing is at fault (see photo 7).

Each of these three factors by itself can be the cause of damage. For this reason they must be examined separately.

Photograph 3. — Excessive shocks are harmful to the stock. The bodies of the wagon get deformed.

Photograph 4. — Example of faulty loading.

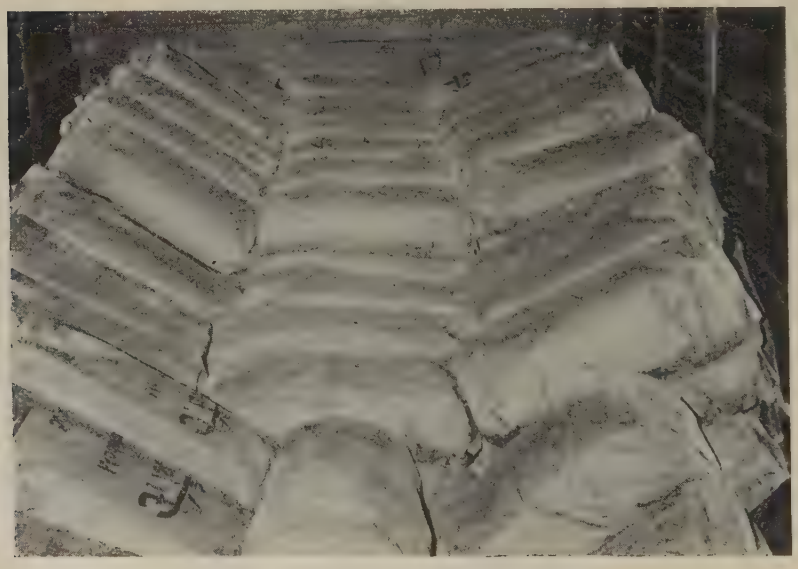
Factor 1.

A fairly high percentage of damage is due to shocks during shunting, the essential cause of which is lack of training of the staff.

The education of the staff in this field can be achieved by :

a) demonstrations; attention is called in the shunting yards to shunting that must be avoided in order to do

Photograph 5. — The load is upset by a normal shock during shunting.



Photograph 6. — Example of correct loading.

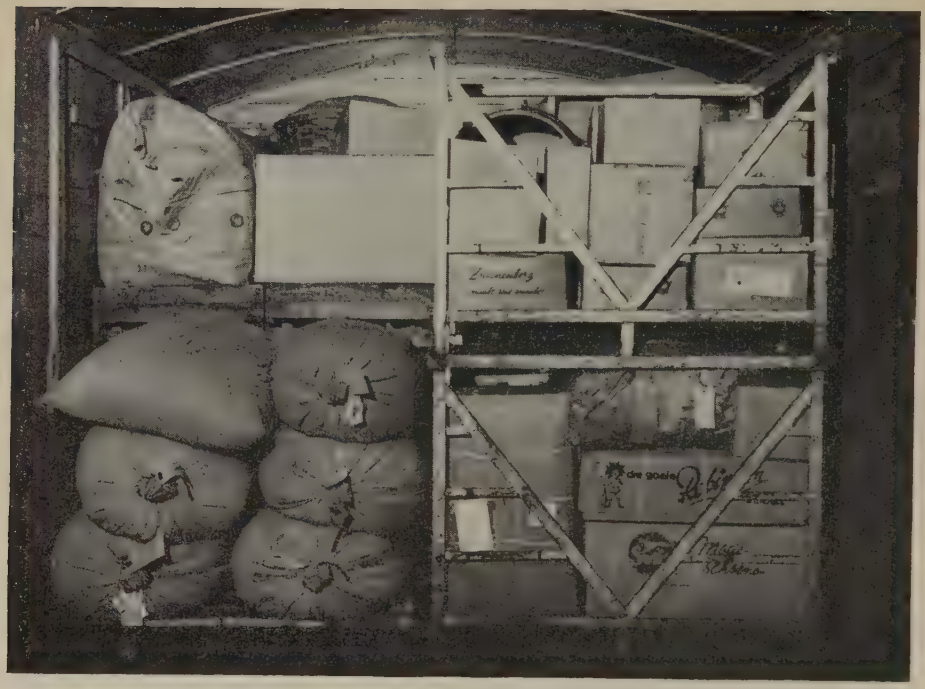
away with excessive shocks. The staff must also understand the working of the shock recorder;

b) lectures at the training school; the teaching will cover the consequences of excessive shocks to the goods and the wagon bodies;

c) lectures given at meetings of the

Photograph 7. — Faulty packing.

Photograph 8. — Modern handling techniques.



Photograph 9. — A wagon part loaded with parcels.

Photograph 10. — Instructing the staff.

railwaymen's unions. These lectures and demonstrations can be accompanied by films.

Factor 2.

A great many cases of damage are due to faulty loading. In this connection, a distinction must be made between part and full loads.

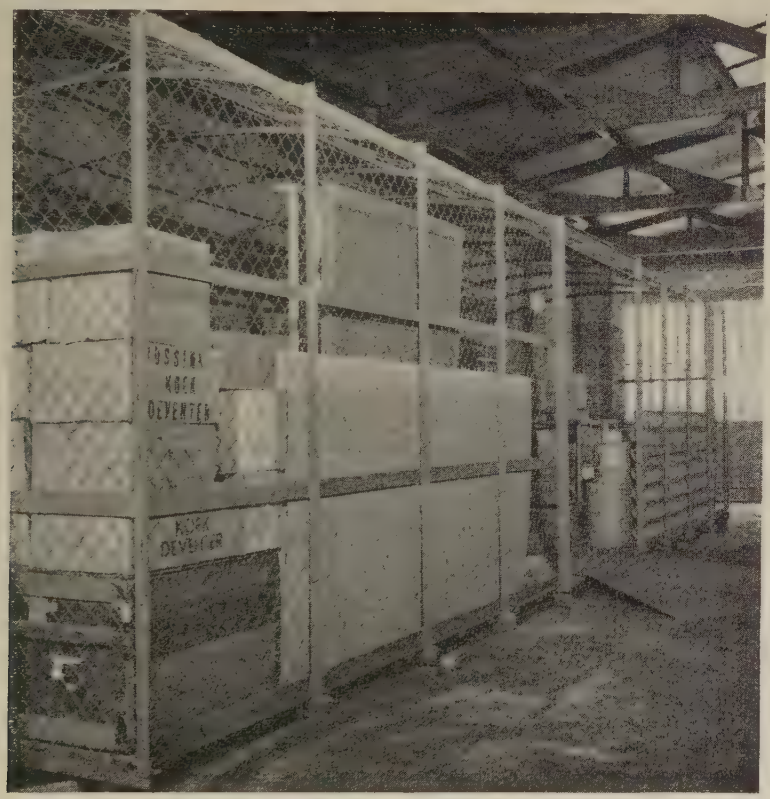
Part loads.

Part loads are dealt with in Holland

by the affiliated company of the Netherlands Railways, the van Gend & Loos Company, who endeavour to encourage correct loading by :

1) modern technical methods (see photos 8 and 9);
2) modern methods of instruction for the staff (see photos 10 and 11).

a certain number of experts who assist at the loading and unloading of consignments which may result in claims being made. These experts take photographs of the load on departure and arrival, and fit the shock recorders. When it is found upon arrival that there were no excessive shocks during the journey and



Photograph 11. — School wagon for loading parcels.

Full loads.

As the consignor is hardly ever present at the arrival of the consignment, he cannot see any mistakes made in loading. Thus, the Netherlands Railways employ yet goods have been damaged due to faulty loading, the responsibility is laid on the consignor. Films are made when such examinations are carried out.

Moreover, we have found on several

occasions that packaged goods were already damaged when accepted by the Railway, and similar damage can also be caused during the final transport after the goods have been delivered by the Railway. For this reason, our investigations begin from the moment the goods leave the consignor's premises and continue until their delivery to destination.

Factor 3.

Damage is often due to faulty packing. If, in spite of high quality transport and perfect loading, damage is found to have occurred (damage due to leaky roofs or derailments are not included here), the client is asked to contact the Packing Laboratory at Delft where the packaging is examined at the expense of the Netherlands Railways. Naturally, the client himself must pay for any improvements in packing recommended by the Laboratory.

The organisation as a whole is known as « Protection during transport. »

Our experience in recent years has led to a new development of « Protection during transport », namely transport surveys.

A study of certain serious damage has enabled the Railway to profit in many cases by the experience which the experts have acquired over many years.

Although a survey of damage occurring cannot as yet be carried out in every case owing to a shortage of experts, there have been many cases where the experts of the « Protection during transport » have been able to convince consignors by means of photographs and films conserved in our archives that the damage must be attributed to faulty loading, so that the Railway was exonerated from responsibility.

Had it not been able to call upon these experts, the Railway would have remained responsible for the damage found on arrival, because the notes proving that before departure the faulty loading had been noticed by the consigning station had not been written in on the waybill, often because of the ignorance of the staff.

The « Protection during Transport » Department now employs 21 men using 33 shock recorders and several photographical and recording instruments.

This department has made possible considerable savings.

To conclude, we would like to say that the Netherlands Railways are always pleased to welcome and instruct those interested in the « Protection of goods during transport », and show them over the Packing Laboratory at Delft.

[621 .132 .8 (43)]

Class 50 locomotive No. 1412 with Franco-Crosti boiler,

by Dipl. Eng. Friedrich Witte, Abteilungspräsident, Minden (Westphalia).

(*Glasers Annalen*, No. 9, September 1955.)

In 1951, for the first time the German Federal Railways put into service two locomotives, class 42[90] with Franco-Crosti boilers. These are boilers with a firebox of normal design, to which is added a feed water preheater, heated by combustion gases, which provides additional heating area; the usual heating surface proportions are consequently modified. The purpose of this method of construction is, in principle, to provide in the two separate units the heat for raising the temperature of the water in one unit and that for evaporation in the other, instead of doing both in one boiler; because of the supply of water already at evaporation point from the preheater, the task of the boiler itself is lightened because it now serves basically only for evaporating the water. The expensive heating surface of the boiler can, because of this reduced demand, in relation to the amount of steam produced, be reduced, since the total drop in temperature — combustion gas/water — is greater in the boiler, the increase from the combustion gases being as much as 100° C on the discharge of the gases from the boiler. The installation of the two parts of the heating surface in two separate units has the additional advantage of adapting the section for passage of gas in the tubes to the variation in volume of the gases during their cooling. The differences of temperature in the boiler itself — between the temperature of the injected water and the temperature of the steam — are reduced; therefore, the thermal fatigue of the elements is also decreased. The evaporation rate of the boiler is excellent. Above all, however, the increased temperature of the combustion gases allows a higher degree of superheat. Moreover, as the feed water injected into the boiler is at evaporation point, the scale forming particles have already been eliminated; from this point of view also the boiler is improved.

These advantages of the system, however, entail the disadvantages that the more pronounced cooling of the combustion gases causes a marked increase in the overall heating surface of the boiler including the heating surface of the combustion gas preheaters. From the thermic point of view, moreover, the subdivision of the heating surfaces can only be an advantage if a greater amount of heat is taken from the combustion gases; if, for example, instead of cooling as at present to 350° C, their temperature is reduced to 160° C, the lower limit in relation to evaporation temperature.

This system has been used for a long time normally in the construction of stationary boilers where the limitations on weight and volume are not so restrictive as in locomotive construction. On the steam locomotive, the combustion gas preheater represents, by comparison with surface preheaters using exhaust gas, or mixing, a constructional complication and additional capital cost which has no general advantage unless the cost of coal justifies the expense. This explains why the sponsor of the combustion gas preheater, the Italian engineer Franco, was able in the first instance to interest the Italian State Railways in his equipment, as they import the greater part of their coal. However, the technical difficulties of a solution really suitable for locomotives have considerably retarded development. Some decades have been necessary for the production of a suitable type of machine which, at the

present time, when the price of coal is constantly increasing, is finding an application by the construction of prototypes in numerous countries where railways use steam traction. It is Professor CROSTI of Milan who, by constant improvement in the theoretical and technical principles of the invention, has the credit for bringing it to its present state of efficiency.

shows the progress made since the Italian locomotive Gr 670 in which the combustion gas preheater is accommodated on a special tender, developing by way of a side-located preheater body on a lateral platform — an arrangement used on converted Italian locomotives as well as on the 42^{90} class German prototypes comprising (fig. 2) two preheater bodies located under

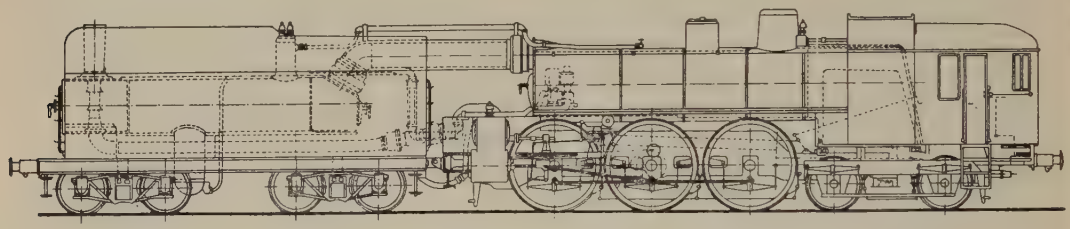


Fig. 1. — Locomotive Gr 670, Italian State Railways.

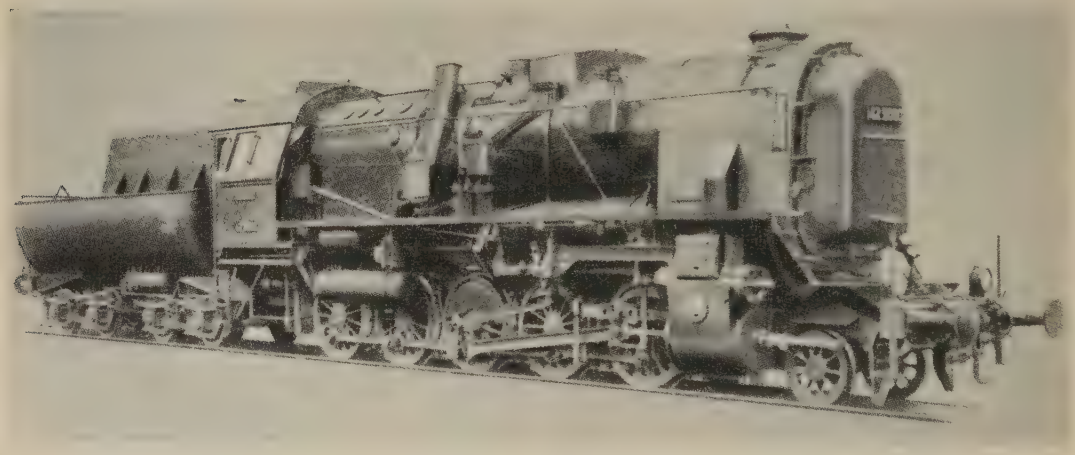


Fig. 2. — Locomotive 42^{90}.

The German Federal Railways have so far participated in this development with three prototypes, the two locomotives 42 9000 and 42 9001, and very recently locomotive 50 1412. The latter, moreover, represents a design which by its general technical arrangement and external form can be considered as a prototype of a class.

Examination of figures 1 to 3 clearly

the boiler, to the design of the class 50 (fig. 3) which comprises only a single preheater located under the barrel. These two arrangements together constitute the two technical possibilities offered by the Franco-Crosti combustion gas preheater. One can either increase the power of the locomotive by converting existing boilers (figs. 1 and 2) or, by the construction of

replace boilers, adapt the preheater boiler to the conversion of energy without modifying the power. In locomotives of class 42[90], the series 50 boiler has been retained and the conversion limited to a modified tube arrangement and firebox.

The increase in power obtained together with an increase in axle load caused the locomotives to be transferred from class 50 to class 42. Systematic line tests with a dynamometer car showed that the locomotives on test had an appreciably increased power. Operation in service, however, also showed that the combustion gas preheater is fairly sensitive to operating conditions, in other words to the state of boiler load, in regard to the usefulness of the additional installation. The more the load of a boiler with a large heating surface is reduced, the lower is the efficiency of the heating surface. It may be that in the case of insufficient load there is no longer a sufficient drop in temperature between the gas and the water at the far end of the preheater. This is the reverse of what happens with an exhaust steam preheater. In general, it provides higher preheating temperature at low and medium evaporation rates than at high rates because of the surplus heat available in the exhaust passage. With the use of the combustion gas preheater, therefore, it is important to calculate the boiler for the power most needed in service and not only for the peak power.

The construction of the boiler for locomotive 50 1412 is designed to clarify these questions. For this purpose, the aim has been to design a Franco-Crosti boiler with *an evaporation rate equal* to that of the normal class 50 boiler, that is, with a maximum production in service of 10 t/h.

The necessity for replacing within the next few years a certain number of class 50 boilers, which were made of St. 47 K steel, a very sensitive steel, by new boilers, provided an opportunity for considering the extent to which the adoption of a Franco-Crosti boiler, in conjunction with the application of new principles introduced since 1950 in new locomotives, could lead to an optimum type, flexible as regards maximum power, and consuming very little coal when partly loaded. The boiler of 50 1412 therefore incorporates all the recent developments in the exclusive use of welding and in the harmonisation of the different heating surfaces, particular attention having been paid to the surface for heating by radiation in the boiler, because of its quality and to the heating surface for low specific load in the combustion gas preheater. We will deal first with the proportion of the heating surfaces and their variation by comparison with the original class 50 type and the intermediate 42[90] type. The main dimensions (fig. 4 and table 1) show the development.

The grate area has been reduced by 22%. In the class 50 it had been relatively large by comparison with other standard locomotives with the idea of

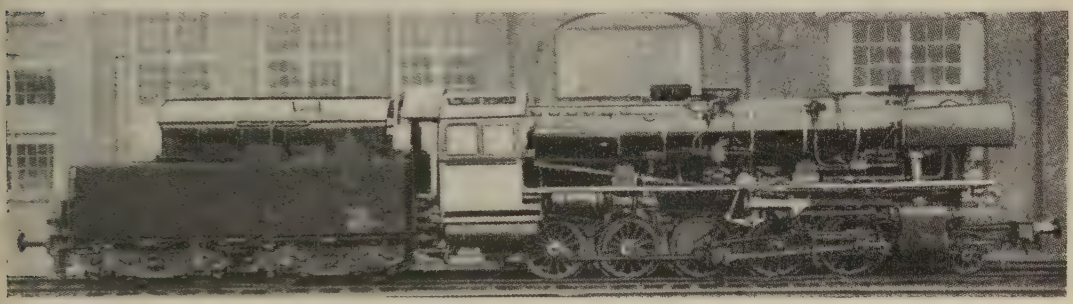


Fig. 3.— Locomotive 50 1412.

burning coal of a low calorific value. In accordance with the principles applied to locomotives built since 1950, and because this is a freight locomotive, it has been reduced to an even lower value than on the class 23 for a similar amount of steam produced by the boiler. This size will allow a reduction in the proportional losses by coal consumption when standing. On the other hand, the firebox heating surface has — also by comparison with class 50 — notable in the superheater, which in 50 1412 measures 52.1 m² (559.831 sq. ft.) or 25 % less than the 50 and even 18 % less than the 42⁹⁰ which moreover gives superheats of more than 400° C.

From line trials it is moreover obvious that the specified 10 t/h could easily be exceeded by 20 %. In the construction of a class to replace the boilers of class 50, a much greater reduction could therefore be made in the total heating surface, which

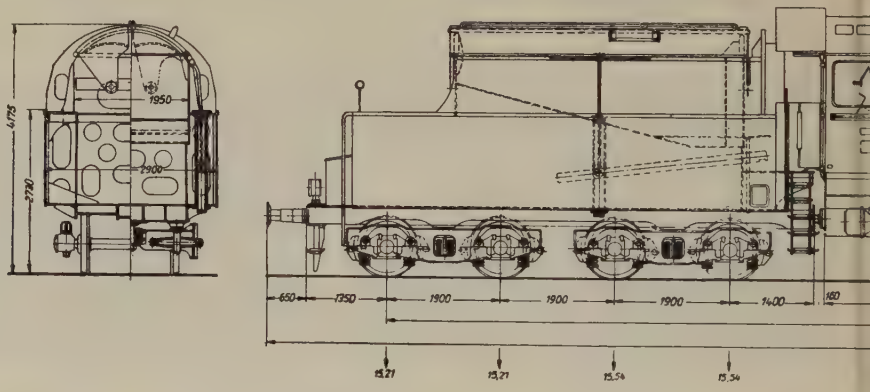


Fig. 4. C

Tender :

Wheel diameter	1 000 mm (3.28 ft.)
Bogie wheelbase	1 900 mm (6.33 ft.)
Total wheelbase	5 700 mm (18.70 ft.)
Spacing of pivots	3 800 mm (12.46 ft.)
Water capacity	26 m³ (918 cu. ft.)
Coal capacity	8 t
Empty weight	27 500 kg (27.06 t)
Weight in working order	61 500 kg (60.52 t)

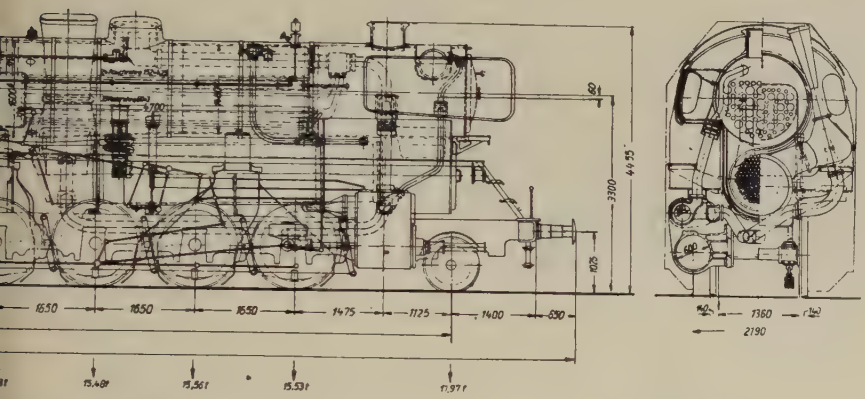
Cylinder diameter	
Cylinder stroke	
Diameter of driving wheels	
Diameter of carrying wheels	
Rigid wheelbase	
Total wheelbase	
Pressure	
Grate area	
Firebox heating surface (gas side)	

been increased by 9 % by the provision of a combustion chamber. Compared with the 42⁹⁰, the evaporative heating surface has also been reduced by 18 % and that of the combustion gas preheater has even been reduced by 30 %. The total heating surface without superheating ,is thus reduced by 23 % compared with the 42⁹⁰ for a reduced steam production of only 16 %. This is the same as saying that the different parts of the heating surface have clearly increased efficiency. This result is especially is a great advantage because the proportion of radiation heating surface will also be increased, the firebox and the grate could remain unchanged, and because any additional reduction, particularly of the preheater, would facilitate installation by reducing size and weight.

Figure 5 shows the boiler of locomotive 50 1412. It has characteristics corresponding to the new principles of construction : wide water legs round the firebox (140 mm wide at the narrowest point); conical shell

at the transition from the barrel to the firebox to provide good supply of water to the radiation heating surface; welding of all fittings, foundations, inspection cover flanges, stays without threads, elimination of stay brackets, welding of the dome foundation, smokebox tubeplate, firedoor opening, firebox frame.

Because of the new dimensions — compared with those of the 42^{90} — it has been possible to replace the two preheater two round doors 4 and 5. The heavy smokebox door of the 42^{90} by which the combustion gases were deflected downwards thus becomes unnecessary. The improvement in external appearance is appreciable and servicing is facilitated. The smokebox 1 carries the auxiliary chimney 9, which is blocked in service by a flap operated by compressed air from the driver's cab. It is not possible to do without the auxiliary chimney, because it serves as an



comotive 50 1412.

Large tube surface (gas side)	50.85 m² (539.04 sq. ft.)
Smal tube surface (gas side)	31.1 m² (333.70 sq. ft.)
Total surface (gas side)	99.25 m² (1065.7 sq. ft.)
Superheater heating surface	52.1 m² (559.82 sq. ft.)
Preheater water capacity	1.93 m³ (32.84 cu. ft.)
Preheater heating surface (gas side)	93 m² (1.001 sq. ft.)
Empty weight	80 400 kg (79.12 t)
Weight in working order	90 350 kg (88.9 t)
Adhesive weight	78 700 kg (77.44 t)
Minimum radius of curvature	140 m (153 yards)
Maximum permissible speed	80 km/h (50 m.p.h.)

m (1.96 ft.)
m (1.96 ft.)
m (4.59 ft.)
m (2.78 ft.)
m (10.82 ft.)
m (30.18 ft.)
m² (2 275 lbs. per sq. in.)
m² (32.30 sq. ft.)
m² (290.95 sq. ft.)

bodies of this class by a single one located under the cylindrical body of the boiler. The whole arrangement is greatly simplified. The smokebox 1 has in the lower part a chamber 2 by the wrapper of which the boiler rests on the frame (cf. also fig. 6). The upper and lower smokeboxes are connected by the plate ducts 7. These ducts 7 rise in the upper smokebox to a height sufficient to ensure that the greater part of the ashes will be held back. The two smokeboxes are accessible through the outlet for the combustion gases through the screens when the locomotive is stabled at a depot.

From the smokebox 2, the combustion gases pass across the tube group of the preheater 10, enter the rear smokebox 3 (cf. fig. 7) and are discharged, as shown by the Section A-A at the side by the blast pipe and chimney 8, located on the left-hand side of the locomotive. Contrary to locomotive 42^{90} which has a chimney on both sides, there is thus only one on this loco-

TABLE I

DESCRIPTION	Sign	Dimension	Series 50	Series 42^{90}	Series 50 1412
Grate area	R	m²	3.9	3.9	3.05
Firebox heating surface	H_{vs}	m²	15.7	15.9	17.3
Large tubes heating surface	H_{Rr}	m²	71.47	65.87	50.85
Small tubes heating surface	H_{Hr}	m²	90.46	39.45	31.1
Evaporation heating surface	H_v	m²	177.83	121.22	99.25
Superheater heating surface	$H_{ü}$	m²	68.94	63.5	52.1
Boiler pressure	pK	kg/cm²	16	16	16
Max. internal dia. of boiler		mm	1 700	1 700	1 570/1 452
Distance between tubeplates	l_r	mm	5 200	5 200	4700
Size of small tubes	d_{Hr}	mm	54 × 2.5	63.5 × 3	60 × 3
No. of small tubes	n_{Hr}	—	113	42	39
Size of large tubes	d_{Rr}	mm	133 × 4	152 × 4	152 × 4.25
No. of large tubes	n_{Rr}	—	35	28	24
Size of superheater tubes	$d_{ü}$	mm	35 × 4	40 × 4	40 × 4
No. of elements of superheater	$n_{ü}$	—	35	28	24
Water capacity of boiler (150 mm above firebox)		m³	7.75	8.45	7.52
Steam space (150 mm above firebox)	D_K	m³	3.0	3.0	2.4
Area of water	O	m²	10.8	10.8	9.66
Empty weight of boiler without mountings	G_{Klo}	kg	19 200	18 500	15 590
Empty weight of boiler with mountings	G_{Klm}	kg	26 300	26 350	19 400
Centre line of boiler above rail	h_K	mm	3 050	3 300	3 240/3 300
Heating surface of mixer preheater		m²	10.45	11.38	10.45
Heating surface of combustion gas preheater		m²	—	128.96	93
Size of heating tubes	d_{Vr}	mm	—	44.5 × 2.5	44.5 × 2.5
No. of heating tubes	n_{Vr}	—	—	206	163
Distance between preheater tube plates	l_{Vr}	mm	—	4 600	4 600
Empty weight of preheater without equipment or smoke box	G_{Vlo}	kg	—	6 350	4 130
Empty weight of preheater with equipment and smoke box	G_{Vlm}	kg	—	6 600	4 300
Total evaporation surface	H_{vg}	m²	177.83	250.18	192.25

motive located on the fireman's side. The passage for the exhaust steam from the main engine to the set of tubes comprising four tubes 60 mm in diameter arranged in line is greatly simplified. The subdivision of the single exhaust so far used into four allows the chimney to be long and narrow and mounted along the boiler without interfering with the visibility (fig. 8). The smokebox 3 is accessible by the door 6 which opens upwards. The weight of the door is balanced by springs. This smokebox receives practically no ashes. The door therefore serves mostly for inspecting the

tubes for tightness. In this locomotive, the tube assembly of the preheater can be withdrawn as a whole through the front. The need for this would seem to be doubtful. It is difficult to avoid the sealing areas being blocked and tar and scale deposits making difficult the extraction of the tube assembly — which in any case requires considerable force. In the series production of locomotives, the tubes would, as in the case of the boiler, have to be mounted in fixed tube plates. The tubes 11 feeding steam to the cylinders are installed laterally outside the smokebox 1 and are consequently very accessible. The whole of the boiler, smokeboxes 1 and 2, the preheater and doors 4 and 5 are insulated with glass wool mattresses.

Special precautions have had to be taken against sulphuric acid damage to the parts of the boiler which come into contact with combustion gases at low temperature. The chimneys 8 of the 42^{90} locomotives were, because of this, eaten away in a very short time. Consequently the smokebox 3, the chimney 8, as well as the exhaust chambers are made of chrome-steel plate. In the series production, it will be necessary to decide whether this steel should also be used for the fabrication of the smokebox 2 and the passages 7.

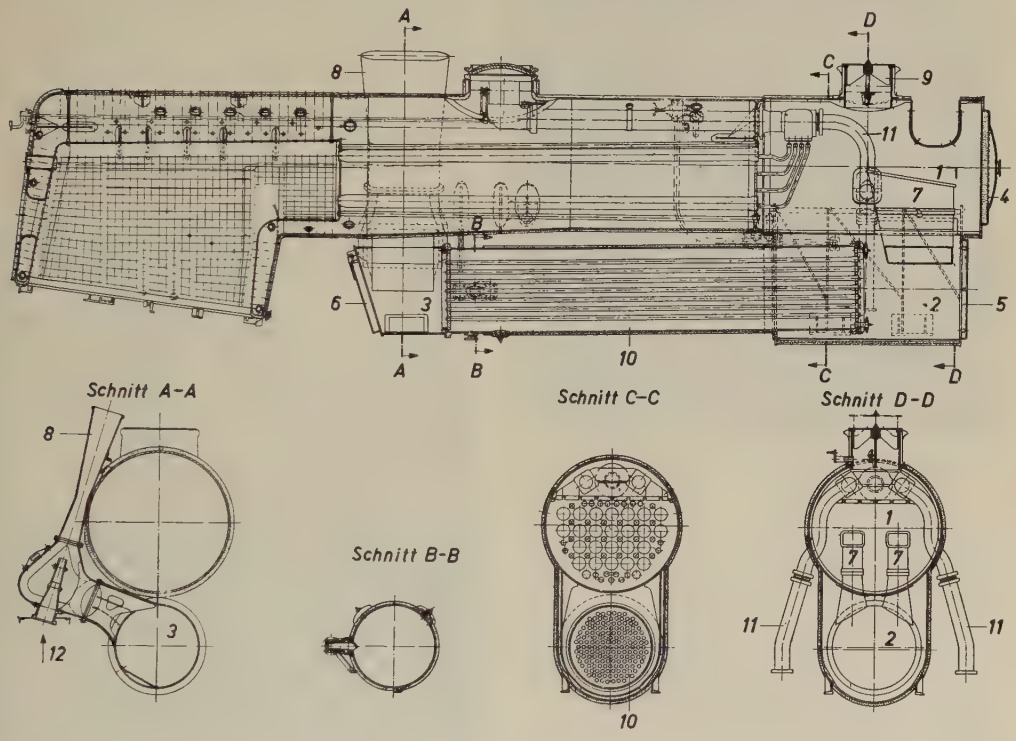


Fig. 5. — Boiler of locomotive 50 1412.

The preheater (fig. 9) is bolted at the front to the smokebox 2 by a circumferential flange, in addition it is hung from the barrel at the rear by a sling plate.

In the 42^{90} locomotive, the preheater was still heated externally, by exhaust steam from the main engine and in its coldest part — where the feed water entered.

As the whole of the exhaust steam was

taken through the casing of the preheater, the counter-pressure was greatly increased. In addition, it is difficult to clean from the preheater body the oil deposit left by the exhaust steam and the transmission of heat is poor. Consequently locomotive 50 1412 has been fitted, in front of the combustion gas preheater with a normal exhaust steam preheater located at the top of the smokebox so that when the feed water reaches the combustion gas preheater it has already been heated to 90° C. The latter component is thus assisted to this extent, and somewhat higher combustion gas temperatures are obtained with a consequent reduced tendency to condensation from the gases. Calculation of the thermal efficiency has shown the advantage of this arrangement of the two stages of preheating.

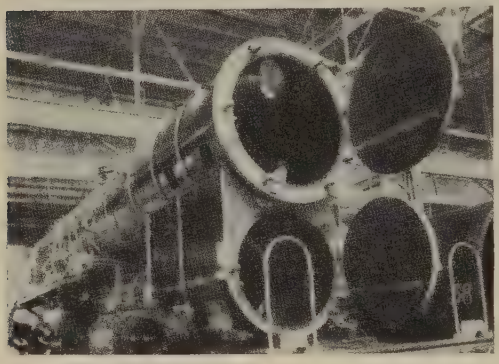


Fig. 6. — Boiler mounted on the frame.

Feed water preheaters using exhaust gas may cause evaporation in the preheater because the gas temperature is higher then that of the steam produced. For reasons of safety, therefore, it is necessary to ensure that pressure in the preheater can never exceed working pressure when, for example, the feed valves of the boiler have to be closed for some cause, or in the event of them not opening. In the piping connecting the preheater with the boiler, therefore two supplementary safety valves have been supplied to limit the pressure in the preheater. The latter will thus have to conform with boiler regulations as it forms an independent boiler : it is consequently provided with two feed water inlet valves, whilst the boiler proper also has two similar valves. On the other hand, it is not necessary to know the level of water in the preheater. Normally, it is always full of water. Moreover, even if steam is formed in the preheater, the heating surfaces could not reach a degree of temperature sufficient to endanger the wrapper as the combustion gas temperatures are not sufficiently high.

For boiler feed, use is made mainly of a KT_1 piston pump with a delivery of 250 l/min. As a second feed, there is an injector (also with a delivery of 250 l/min). The KT_1 pump supplies water through the exhaust steam preheater to the combustion gas preheater and so to the boiler. In the prehaeter, therefore, there is a pressure in excess of the boiler pressure because of the resistance of the pipes and feed valves. As the piston pump always delivers through the combustion gas preheater, there is no risk of feeding cold water to the boiler whilst coasting or standing. The pump can thus be used at any time.

The injector delivers to the combustion gas preheater. When it is in use, the heat of the combustion gas is therefore recovered. The delivery pipe from the injector is divided into two branches, one leading to the pre-

Fig. 7. — Rear smokebox.

heater and one directly to the boiler. The latter branch can be used by setting a cock which is normally sealed, for example, in the event of loss of water because of a perforated tube in the preheater. This by-pass should be used only in emergency.

As it is important to ensure, without any excessive expense, that the heating surfaces are clean, particularly the combustion chamber, and especially when in service, the boiler is fitted on the back wall of the firebox with a Gartner type steam ejector, combined with a Gestra quick-acting valve (1).

It has been necessary to make a slight modification to the radius rod, its position being taken by the preheater. It has been dropped sufficiently to allow movement

Fig. 8. — View from driving cab.

(1) See also « Die Lokomotivtechnik », 1955, nº 5.

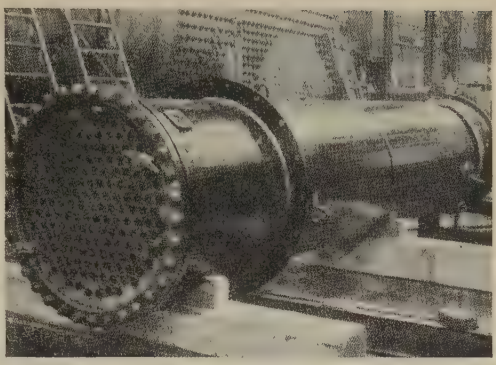


Fig. 9. — Combustion gas preheater.

from one side to the other under the preheater. It has been necessary to provide short intermediate shafts and a diversion rigging from each side of the locomotive to the former suspension bracket behind the slide bar (fig. 10).

Particular care has been taken to protect personnel from the exhaust gas. On the cab roof, parallel to the roof plate, is a deflector plate which uses the draught when running to relieve the low pressure zone behind the cab roof. By this one fact, a considerably reduced amount of combustion gas is drawn into the cab. When the coal is reduced, however, it is not possible completely to protect the cab by way of the tender. Consequently, the tender has also been provided with a baffle covering the whole of the coal bunker.

For this purpose, use had already been made of sliding covers, as on the tenders of streamlined locomotives of series 01^{10} and 03^{10}, as well as the 05. These had not given lasting satisfaction as the cover plates wedged very easily. The new arrangement, figure 11, comprises two half covers which can be drawn back over the sides on to the top of the tender, hinged along the tender centre line. These two half covers have a cylindrical curvature which makes them particularly rigid and free from distortion or billowing. They are formed on a tubular frame covered with plate on the two ends, which increases their rigidity without greatly increasing the weight. The

half covers are mounted on conical roller bearings fitted to the front and rear walls of the coal chute by segmented arms. The longitudinal thrust caused by the mass of the covers is taken by rollers on the end walls. Each cover is operated by a compressed air lifting cylinder. The covers are locked mechanically to avoid accidents, that is they can only be moved by compressed air after the lock has been released manually.

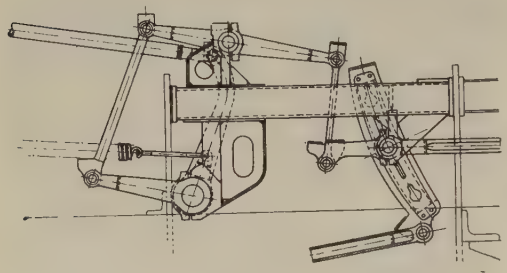


Fig. 10. — Valve gear modification.

This arrangement is not in itself an essential element of the Franco-Crosti locomotive, but the construction of the locomotive has provided an opportunity for testing it since it would be appropriate to provide all passenger locomotives with the means of avoiding dirtying carriages by the deposition of dust and oil as well as by spraying water when moving coal. Figure 3 shows the cover in the closed position. It could easily be fitted to existing tenders.

Advantage has been taken of the conversion to fit at the same time a wheel flange lubricator supplied by Woerner of Stuttgart.

By systematic tests with a dynamometer car, measurements have been made of the efficiency of the boiler, consumption of fuel, preheating of feed water, superheat, draught efficiency and combustion conditions.

A comparison has been made with the calculated corresponding values for locomotives 42^{90}, 52 821 fitted with a Heinl mixer preheater and 52 875 fitted with a Henschel mixer preheater.

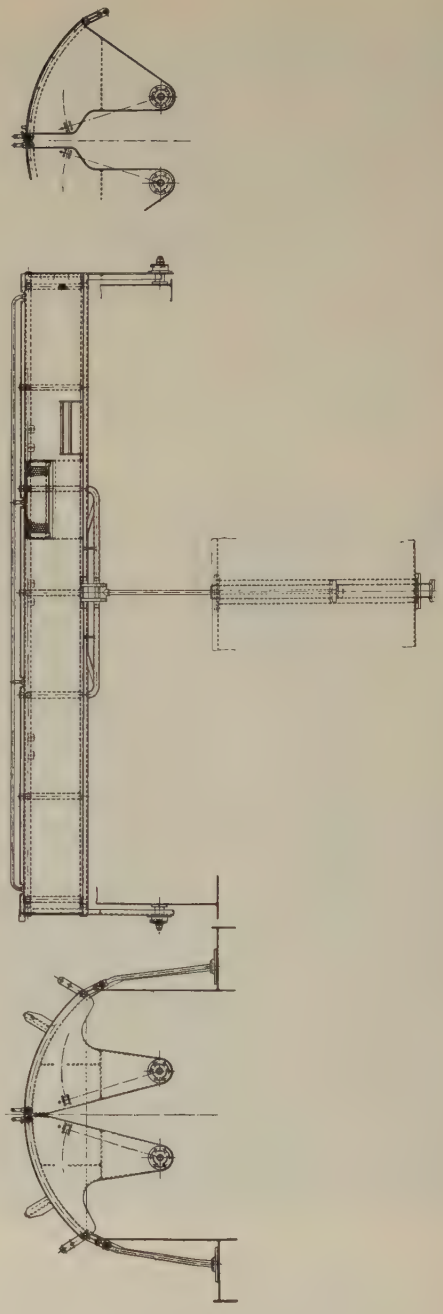


Fig. 11. — Cover for coal bunker.

The converted boiler has worked perfectly at all imposed loads. The powerful draught acts uniformly on the fire at all parts of the grate thanks to the well-arranged air inlets in the ashpan so that the boiler has a high evaporation capacity. The productive limit of this boiler is $D \approx 12$ t/h or 20 % more than the maximum of the series 50 boilers ($D = 10$ t/h for a combustion rate $b_H = 57$ kg m²h).

From the values measured, the specific consumption of fuel B' (kg/min) of locomotive 50 1412 is about 3 % lower than that of locomotive 42 9000. In figure 12, we have presented this specific consumption in relation to the production of steam D (t/h).

The preheating of feed water in two stages (mixer preheater and combustion gas preheater in series) gives (fig. 13)

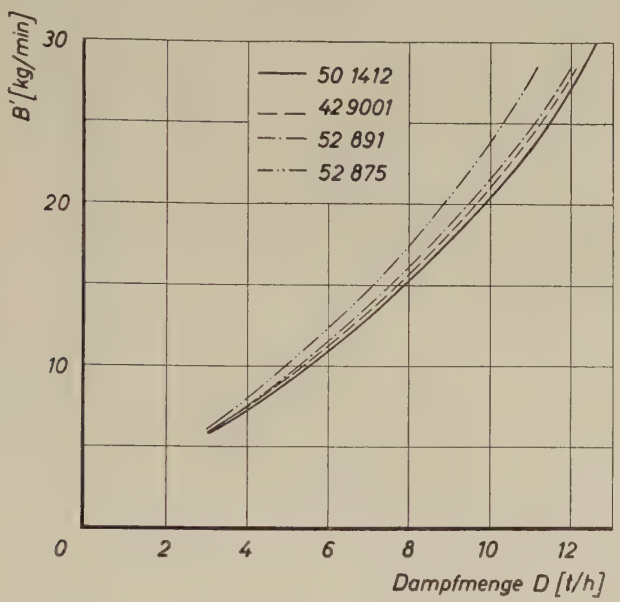


Fig. 12. — Coal consumption in relation to steam production.

This limit is determined :

— by the physical capacity of the firemen;

— by the humidity of the steam which at rates of steaming $D > 12$ t/h increases considerably — up to $D = 12$ t/h, no drawing of water despite the low area of water surface $O_W = 9.66$ m² against 10.80 m² in boilers of the 50 and 42^{90} series.

— by the combustion, because the power of the draught when the boiler is heavily worked pulls an increasing amount of fine combustible matter from the firebox — and this burns or forms cake in the smokebox.

higher feed water temperatures with a reduced heating surface in the combustion gas preheater ($H_{Rv} = 90$ m² against 129 m² in the 42^{90}) than with single stage combustion gas preheating of locomotive 42 9000, the casing of which is heated by the whole of the exhaust steam. At low rates ($D =$ about 3 t/h) the difference in the temperatures of the feed water rises to 30° C. In the range of medium rates ($D = 5$ to 8 t/h approx.), it rises to 35° C falling to less than 20° C at heavy rates ($D > 9$ t/h). The result is that with the most usual rates of steaming — during running at moderate speeds — there is

available feed water at a higher temperature.

In the surface preheater (heat exchange area = 10.45 m²) the preheating falls constantly in proportion to the increase in steam production. When D = 3 t/h, the feed water leaves the preheater at a temperature of 94° C and at normal evaporation at about 88° C.

In the combustion gas preheater, the preheating increases with the evaporation from the boiler from 140° C when D = 3 t/h up to t_{sp} = 162° C when D = 10 t/h.

For preheating of feed water, the combustion gases are cooled by 200° C (from ≈ 490° C to ∼ 190° C) at the normal production rate of the boiler, and, at D = 3 t/h from ∼ 260° C to ∼ 140° C. At this rate of production the feed water leaves the combustion gas preheater at the same temperature as the gases.

The differences of temperatures of the combustion gases and the feed water at various rates of steam production (D) and the dissimilarity of the temperature curves

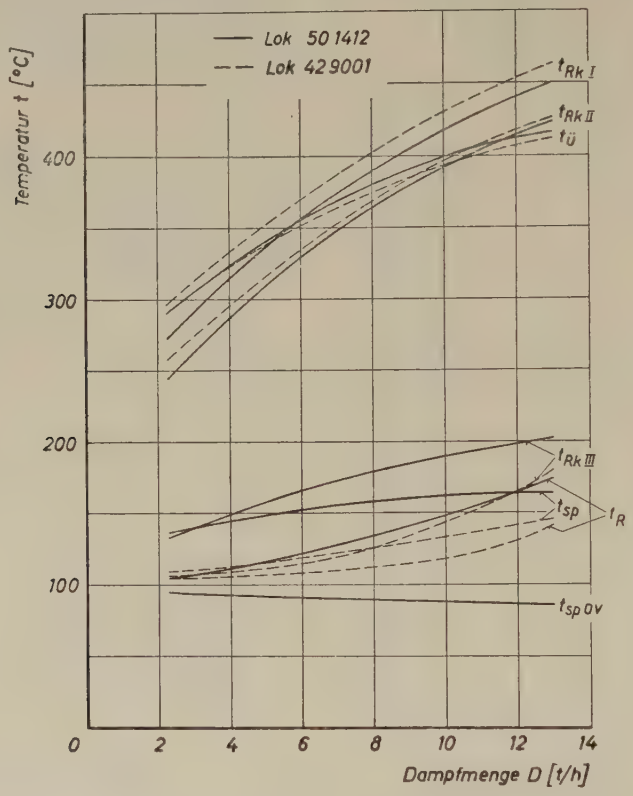


Fig. 13. — Temperatures of combustion gas, feed water and steam.

(t_{Rk} and t_{sp}) result from the difference between the types of preheating equipment fitted to the two locomotives compared.

In the preheater of locomotive 50 1412. the combustion gases cannot be subject to such a degree of cooling since with the reduced heating surface (the water enters at higher temperatures (t_{OV} ∼ 94 to 88° C instead of t_T ∼ 8 to 12° C).

As the feed water is supplied only *with the heat from the combustion gases* which

increases constantly with the amount of water as the production of the boiler increases (see temperatures t_{RKII}), the curves of combustion gas temperatures and feed water show the same tendency.

The feed water of series 42^{90} locomotives on the contrary, receive a part of the heat in the *combustion gas* and in the *whole of the engine exhaust steam.* An increase in the production of steam corresponds to an increase in the two temperature curves. The exhaust steam temperature curve has a shape symmetrical with that of the temperature in the smoke box. This results in a curve representing the total available amount of heat in the preheater, which increases slowly within the range of low and medium efficiencies and rapidly in the high efficiency range. The feed water temperature curve (t_{sp}) of locomotive 42 9000 also shows the same tendency.

The preheater, with a water capacity of nearly 2 m^3 also constitutes a good heat store, which has a favourable influence in service. Even during long periods of standing or running with closed regulator, it was always possible during the line trials to feed the boiler with preheated water. In fact, even in these conditions, combustion gas was available for heating the preheater; in view of the high capacity of the preheater, the preheating temperature falls slowly. The boiler can be fed at any time, therefore, exclusively by the feed pump. If this is stopped, or set to give a low rate of delivery, the water in the preheater is brought up to evaporation temperature. The steam produced in the preheater then

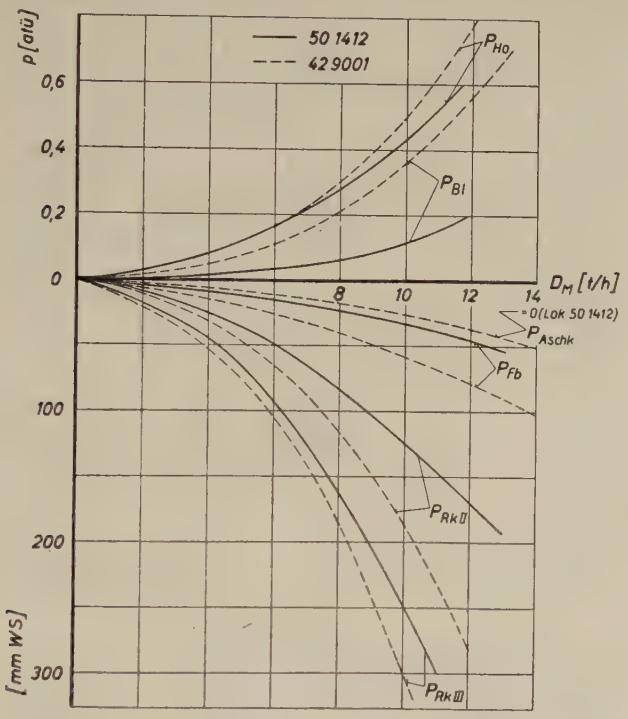


Fig. 14. — Variation of pressure during the passage of the combustion gas through the boiler.

passes to the boiler. Any excess heat is thus fully used.

The temperature of the superheated steam, measured in front of the distributor, has been found to be equal to $t_{ü} = 400^{o}$ C at the normal production of the boiler and to $t_{ü} = 350^{o}$ C when D = 3 t/h. The temperatures of superheated steam of locomotive 50 1412 and of locomotive R. 42^{90} in test locomotive 50 1412 and locomotive 42 900, in relation to the amount of steam used by the engine (D_M).

In view of the different designs of blast pipes (bodies) in the locomotives being compared, the pressures in the pipes give no useful information on the efficiency of the blast equipment.

On the other hand, the pressure in the

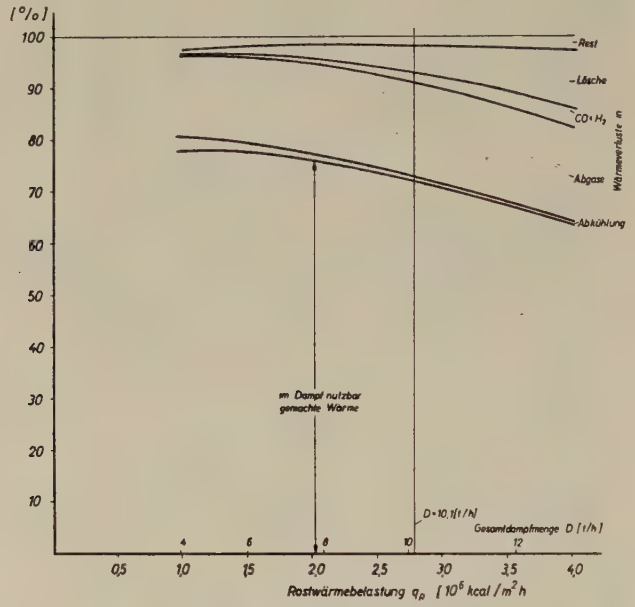


Fig. 15.— Heat balance of the boiler.

Note. — Rostwärmebelastung = thermal fatigue of the boiler. — Gesamtdampfmenge = total quantity of steam produced. — Im Dampf nutzbar gemachte Wärme = heat available in the steam. — Wärmeverluste in... — heat losses in... — Abkühlung = cooling. — Abgase = combustion gases. — Lösche = unburnt material. — Rest = remainder.

are identical in the range of low steam production. Above D = 4 t/h, the superheat of locomotive 50 1412 increases more rapidly with the load on the boiler and at D = 10 t/h, it is 6^{o} C higher than locomotive 42 9000.

Figure 14 shows the variation of :

pressure at blast pipe. . . .	(p_{Bl})	atm
pressure in breeches pipe . .	(p_{Ho})	atm
pressure drop in ashpan . .	(p_{Aschk})	mm water
pressure drop in firebox. . .	(p_{Fb})	atm
pressure drop in smoke boxes II and III	(p_{Rk})	atm

breeches pipe is, in the two locomotives, connected with the counter pressure in the engine by an almost identical ratio. In locomotive 50 1412 this pressure increases less quickly with an increase in the amounts of steam used by the engine, which must be attributed to the fact that the exhaust passage gives a lower resistance than the heating wrapper of the combustion gas preheater of locomotive 42 9000.

To the lesser pressure in the breeches pipe (i.e. appreciably the counter pressure in the engine) corresponds also a depression t_{RkIII}, therefore a lower draught; at

D = 10 t/h it is about 20 % lower than in the smoke box III of the locomotive 42 9000.

To obtain good combustion — which moreover has also been obtained in the boiler of locomotive 42 9000 — a lower pressure drop t_{RkIII} would be sufficient here — as with the well proportioned

From analyses of combustion gases, the losses by imperfect combustion in the boilers of the two locomotives compared are very much the same.

The excess air, calculated from the composition of the combustion gases shows that draught and combustion conditions are good. Over the whole range of steam

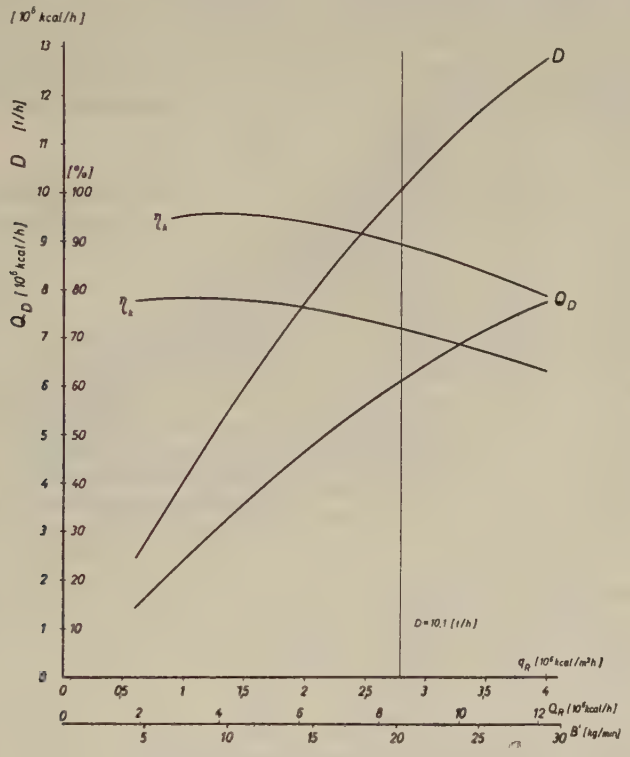


Fig. 16. — Production of steam and heat content of steam, also boiler efficiency.

ashpan inlets, the air for combustion need not be blown on the grate, and the resistance in the evaporation of the boiler of locomotive 50 1412 is lower than in locomotive 42 9000, so that with equal grate resistance of the locomotives compared, the slightly higher resistance of the combustion gas preheater has no unfavourable effect on the rate of combustion; it is in fact an advantage in relieving the peak pressure drops.

production excess air varies from 1.47 to 1.25 at increasing load for values of CO + H2, which are little higher.

Figure 15 shows the complete heat balance of the boiler. The greater part of the ash is retained in the first smoke box. A small part only has been extracted from the combustion gases in the second one. In box III have been found only insignificant amounts of fine unburnt material. It can be accepted that emission by the

chimney is practically nil. In addition, with the long passage of combustion gases and judicious arrangement of the air intake the draught plays on the fire over the whole of the grate in a manner so uniform that even at heavy rates of combustion there is no picking up of the fuel. This also affects the heat balance. The heat contained in the gas leaving the boiler is naturally great because of the relatively small size of the boiler compared with the normal type, which is in accordance with the Franco-Crosti boiler principle. Figure 15 however shows that this is only an apparent loss since this heat is recovered in the combustion gas preheater.

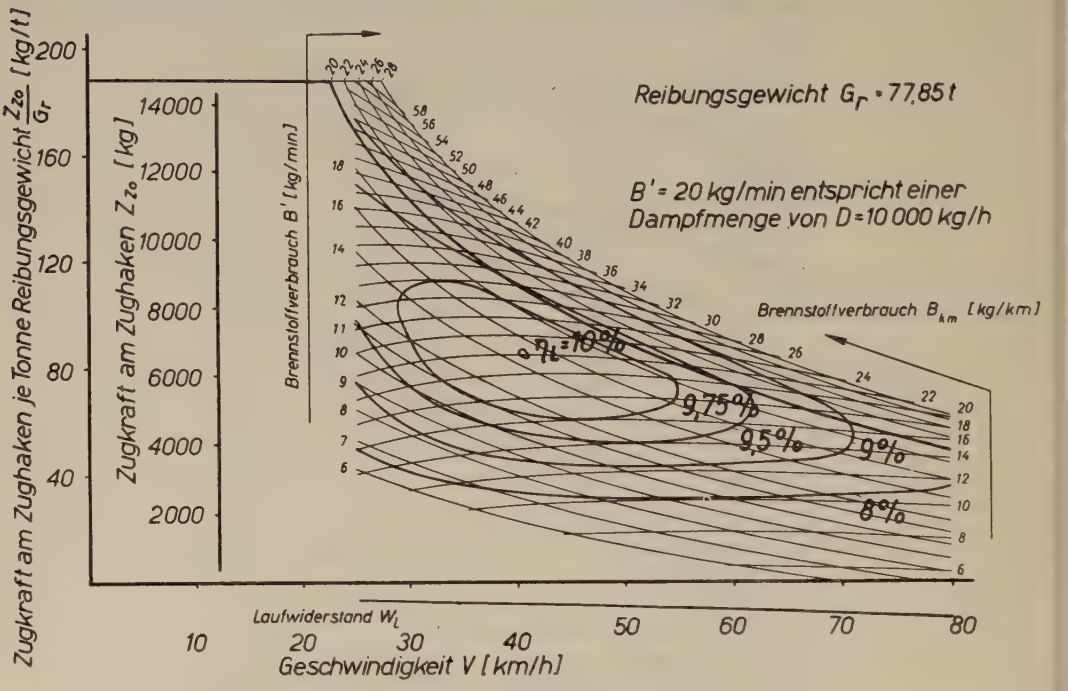


Fig. 17. — Caracteristic curves.

Geschwindigkeit = speed. — Laufwiderstand = resistance to movement. — Reibungsgewicht = adhesive weight. — Brennstoffverbrauch = fuel consumption. — B' = 20 kg/min entspricht... = B' = 20 kg/min corresponding to a steam production of D = 10 000 kg/h. — Zugkraft am Zughaken je Tonne Reibungsgewicht = Tractive effort at drawhook per ton of adhesive weight.

losses comprise almost exclusively the heat losses in the amount of ash; the remainder, which also includes loss from unburnt particles in the ash, is remarkably low by comparison with other locomotive boilers where this remainder also has a tendency to increase very rapidly with increased load because emission through the chimney increases heavily and reduces the amount of ash left in the smoke box.

Losses by cooling of the boiler are low because of its small dimensions and especially because of the excellent insulation of the boiler and smokebox.

Figure 16 shows as a function of the thermal fatigue of the grate q_R, the total quantity of steam produced D and the total quantity of heat contained in the steam Q_D, as well as the efficiencies η_K of the boiler itself and of the complete steam

producing installation η'_K, the difference between η'_K and η_K measures the effectiveness of the preheaters. It may be noted that whilst the heat contained in the exhaust gases may be considerable, the efficiency of the actual boiler is practically the same as that of the former boilers of series 52 and 50.

The gain in heat due to the whole of the surface and combustion gas preheaters varies from 18 to 15.5 % of the energy supplied by the coal.

Figure 17 shows the characteristic curves of the locomotive. The maximum efficiency is 10 % at about 40 km (25 miles/h).

Test results provide reason for hoping that the locomotive thus modified will also give good results in service. Like the two 42^{90} locomotives, locomotive 50 1412 was designed and built by Henschel and Son of Cassel, in close collaboration with the Minden Central Office of the German Federal Railways. The results of the tests have been based on precise dynamometer car measurements made by the Minden Locomotive Testing Service.

[656 .257]

Thoughts on the automatic routing of trains,

by Doctor-Engineer, Professor Walter Schmitz.

(*Signal und Draht*,(*) No. 12, December 1955.)

Summary. — The present article contains a theoretical study investigating the question to what extent it is possible to set up automatically, by means of technical apparatus, the routes of all trains of a large network in normal operation. It is accepted that the control official must be able to intervene at any moment in case of irregularities in operation.

With the present method of operation, the local official in charge of train operation (Fahrdienstleiter) sets up a train route, either alone or with the collaboration of one or several signalmen. Normally, all the operations required for this purpose, e.g. for a passenger train, are wholly predetermined. For, the route of the train is exactly laid down in the timetable from the departure station to the destination station, including all intermediate stations with their respective timings. Similarly, the route taken by the train within each station is fixed, as the tracks to be used by each arriving, departing or through trains are laid down in the local operating schedule of each station. It follows that the function of the control official will normally be confined to the operation of points and signals in accordance with a prearranged sequence, with numerous operations which repeat themselves. The official must however intervene and take the measures appropriate to the situation in the case of irregularities in operation, i.e. when the sequence of trains is changed, or when the trains are late or may even have to use a different route through the station. It is conceivable that normal operation, corresponding to the great majority of train movements, can be ensured by an appropriate technical device, viz. an automatic train-routing installation where the control official only intervenes in case of irregularity. With such an installation, the automatic apparatus would even be able to deal with trains that are running late provided that the route of the train through the station is not occupied at the time. It would even be possible to make provision, in the automatic installation of the station, for the use of an alternative route which would be used if the scheduled route is occupied. For this purpose, it would be particularly desirable to choose the platform road on the other side of the same island platform so that interference with passenger, luggage and mail movements is minimized. The change of platform would be accompanied by an automatic loudspeaker announcement. In that case, the official would not take over the control of traffic from the automatic controller until the latter has exhausted all pre-set alternative possibilities. As the control official is only called upon to intervene in case of irregularities, he is in a much better position than before to deal rapidly with a complicated situation, as he is no longer concerned with normal operation. For, if the station has several platform roads, not all of them are likely to be affected by the irregularity. In any case, any irregularity must be suitably reported to the control official.

It is at junctions that the installation of an automatic routing device appears to be easiest to carry out. If two trains converge on a junction, priority should logically be accorded to that train which is the first to arrive in the vicinity of the junction. This

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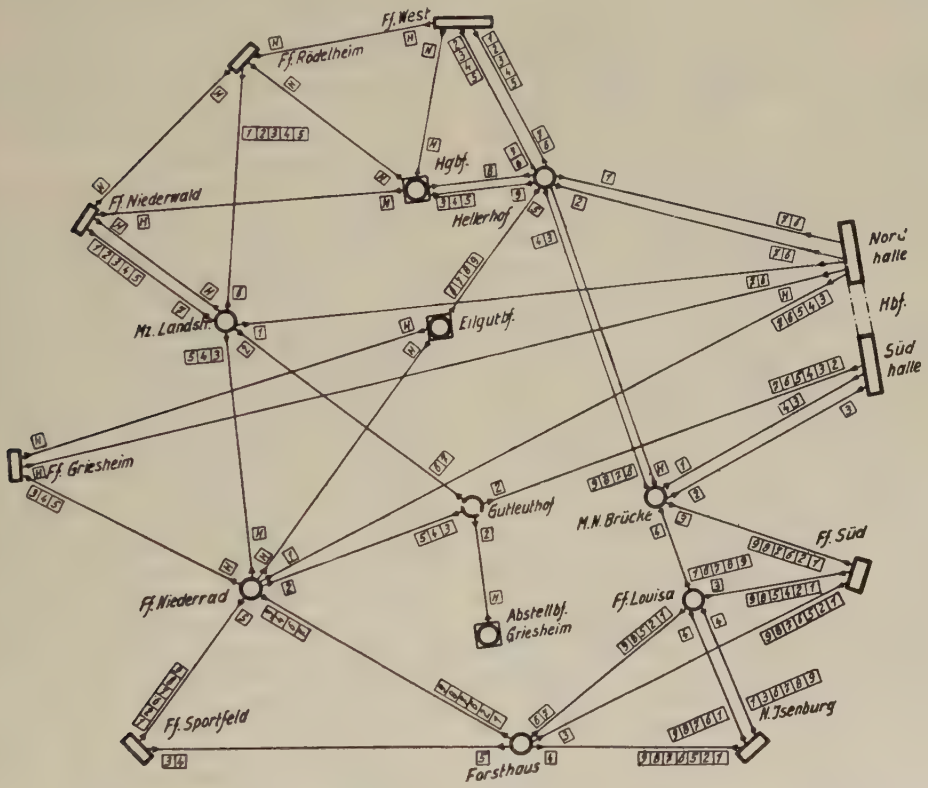
train will then occupy its route and, having cleared the converging points, will permit the automatic setting up of the route for the second train. The problem is thus very simple with trains of equal priority where the first train to arrive is allowed to pass first. It is of course also possible to accord priority, in all cases, to one of the two lines. Equally, it is possible to accord priority to certain trains. For this purpose, however, the only criterion available is the train number indication or the train number itself. This number would have to be given a supplementary characteristic by which the train could be distinguished from one of a lower priority.

As far as diverging movements are concerned, it is in any case necessary to distinguish betwenn the trains. Here, the installation might be so designed that each train number indicates, to the junction box or the automatic installation, by means of a certain code, the route which the train wants to take, or in other words, whether



Key :

1. Frankfurt Central Station. North Hall and Northern Part of South Hall.
2. Frankfurt Central Station. South Hall and Southern Part of North Hall; carriage sidings.
3. Frankfurt-South Station.
4. Isenburg Station.
5. Frankfurt. - Sports Ground Station.
6. Frankfurt. - Rödelheim Station
7. Frankfurt Niederwall Station and Frankfurt West Station.
8. Main Goods Yard « Centre ».
9. Main Goods Yard « South ».

H. Manually operated.

○ = Remote controlled operating post.

◎ = Operating post where train routing codes are selected.

▭ = Outlying station where train routing codes are selected.

Hgbf. (= Hauptgüterbahnhof) = main goods station. — Eilgutbf. = express goods station. — Abstellbf. = carriage sidings.

Fig. 1. — Train routing code system in the Frankfurt-on-Main zone.

the train is to be directed to the right or to the left. There is also the possibility of according priority to one line in such a way that the code would only be required for trains which want to branch off from the main direction. It is of course an essential condition that these control indications and the train number are transmitted from the preceding section to the signal box (in this case the junction box) so much in advance of the arrival of the train that the signal can still be cleared in good time.

In Germany, the first installation of this kind is being provided in connection with the construction of the new central signal box at Frankfurt Main (fig. 1). Shortly before reaching the Frankfurt signalling zone, the trains arriving on the different lines are given a certain code which might be compared with the route number of a tram route, and which determines the entire route to be followed from the running line concerned to the station proper so that, on their journey, the trains find their way automatically. The converging lines carry, right up to the station itself, a route number, e.g. 1 to 9. For instance, a train coming from the South may carry the route number « 6 ». This route number, in conjunction with the train number, precedes the train from one diverging or converging junction to the next until the train enters the station zone itself. This route number thus governs, all along the route, all the diverging and converging points where the latter, as already mentioned, are automatically controlled without special priority. In the normal case, the controller in charge of the Frankfurt/Main zone is therefore relieved to a very great extent by the automatic operation of the diverging and converging points, and need not intervene except if there is any irregularity. This control method based on the use of route numbers is, in his case, a reasonable proposition because all trains either terminate at one point or fan out from that point via the shortest route.

As the next step, it is possible to extend the automatic routing method to entire stations or to the whole trip of a train. In principle, it is even possible, with the technical means at present at our disposal, to extend automatic routing to the entire system of a Railway Administration. At first glance, this may appear to be a utopian proposition. There are thus at present, on the network of the German Federal Railways about 34 000 trains per day, including some 20 000 passenger trains. As regards the remainder, i.e. the freight trains, it would be more difficult to include them in the automatic control because these trains do not all work in regular paths but often in optional or special paths. In principle, this difficulty can however be overcome. Nevertheless, it is now proposed to examine if and how it is possible to establish an automatic routing system for the entire area of a large railway system.

The 34 000 trains to be dealt with every day have, in normal operation, precisely determined workings, characterized by train number (Z), time (T) and place (O), i.e. the section of line, or the station road laid down in the local operating schedule of the station, so that every phase is defined by ZOT. These data are sufficient to serve as a basis of an automatic train routing system. In conjunction with the train numbers, train routing codes (ZLN) are transmitted automatically from signal box to signal box over appropriate transmission channels. As is well known, the train number conveys all the indications related to the working of the train, its timetable, its locomotive roster, the station movement schedule, the transfer of through carriages etc. whilst the routing code (ZLN) derived from it permits the setting up of the train route on the section of line ahead.

To illustrate the process in the simplest way, we may consider the part of the working of a train comprised between two junctions (Kn) and (Kn + 1). The term *junction* may here be taken to comprise any track layout where more than two single-track or multiple-track sections converge. As already mentioned, the simplest case is that of a junction where three sections of line meet (fig. 2c).

At an intermediate station, only two

sections of line converge (fig. 2*b*) whilst a terminal station is only served by a single section of line. (fig. 2*a*).

A junction can be the converging point of any number of lines (fig. 2*d*). Neumünster station, for instance, is the meeting centre of seven converging sections.

With the German Federal Railways, the number of junctions thus defined are as follows :

Number of converging section of line.	*Number of junctions.*
1	258
2	Approx. 4 500
3	580
4	195
5	68
6	18
7	3

Fig. 3*a* shows a train running over the through roads of junction (K*n*) and those of the consecutive intermediate stations (ZB *n* ...) to the following junction (K*n* + 1). To set up the routes ahead of the train, it is therefore only necessary to include a transit code in the train routing code (ZLN) transmitted with the train number (Z). The control zone of a junction (K*n*) always includes the following line right up to the next junction (K*n* + 1).

In such a routing section of a control zone, there are three alternatives to normal through working :

1) The train uses a loop road (ÜK) at junction (K*n*) (fig. 3*b*).

2) The train uses a loop road (ÜS) at any of the intermediate stations (fig. 3*c*).

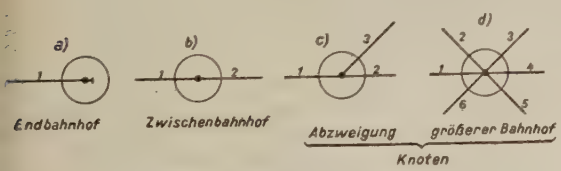


Fig. 2. — Categories of stations.

Key : a) Terminal station.
b) Intermediate station.
c) Junction.
d) Major junction station.

3) At the junction, the train is diverted via (A) to a different section of line (fig. 3*d*).

4) Any combination of cases 1 to 3 (fig. 3*e*).

In this connection, it is assumed that, within the junction station, one of the lines is regarded as through road. At a major junction station, this function may

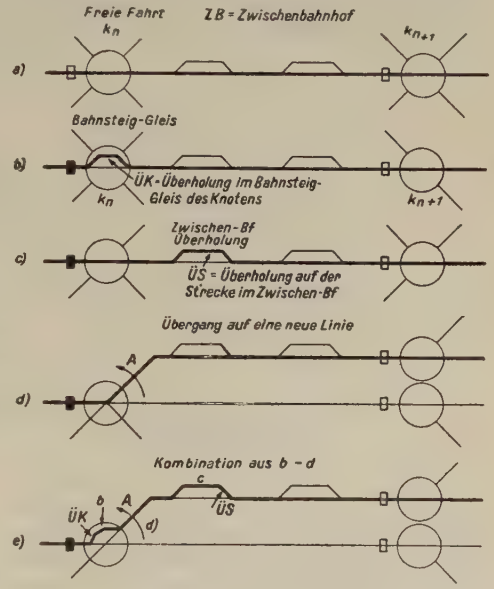


Fig. 3. — Alternative routings within the automatic routing zone.

Explanations of German terms :

Freie Fahrt = clear road. — ZB = intermediate station. — Bahnsteig-Gleis = platform road. — ÜK = train being overtaken while standing in loop road of junction station. — Zwischen-Bf. Überholung = overtaking at intermediate station. — ÜS = train being overtaken while standing in loop road of intermediate station. — Übergang auf eine neue Linie = transfer to another line. — Kombination aus *b-d* = combination of cases *b* to *d*.

be assigned to several lines, independent of each other (fig. 4).

Each running line converging on a junction must be connected with the routing code storage device to which we shall revert in greater detail later on.

The train number (Z) transmitted ahead of the train enquires automatically from the ZLN storage device the routing pro-

gramme for the next section of line, up to the next junction.

The reply may be that the train (identified by its number, say 363) is meant to continue through the junction to follow the same route number, e.g. route 25, either by using through road No. 1, or a loop road No. 3, or alternatively that the train 363 is diverted to another route, e.g. route 40, using the corresponding through road No. 2, or a loop road No. 4.

The routing code consists of :

the number of the loop road at the junction	ÜK	3
the number of the route and the number of the intermediate junction	K*n*+*m*	25.15
the number of the station where overtaking takes place, and of the loop road used	ÜS	02.3
and the code number of junction K*n*		05.4

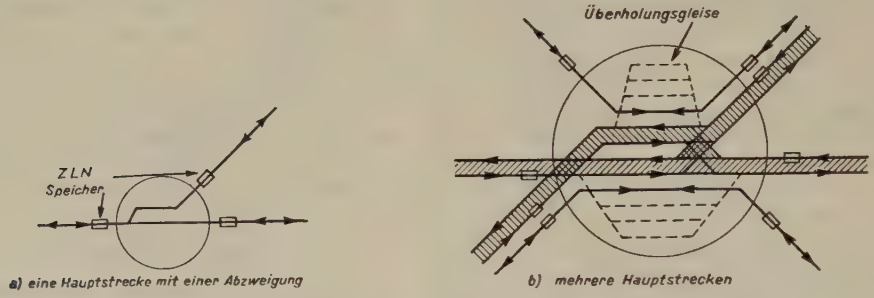


Fig. 4. — Junction station with one and several main lines, respectively :

a) One main line with branch.
b) Several main lines.

ZLN Speicher = train routing code store.
Überholungsgleise = loop roads.

Moreover, the train may be routed say, via loop road No. 3 of the second intermediate station and loop road No. 4 of the fifth intermediate station, using the through road at all other intermediate stations. At the following main junction, the train receives another ZLN code if it is there to be diverted in any of the ways shown in Figs. 3*b-e*, and this is repeated until the train has reached its destination. If the train passes through several junctions in succession, using the through road all the time, without being diverted in any of the ways shown in Figs. 3*b* to *e*, the train continues with the same code until reaching junction (K*n* + *m*) and receives no further ZLN code except at the junction where it must leave the through road.

Train number (Z) and routing code (ZLN) might therefore be as follows :

363 3/25,15/02,3/05,4...

where 325,15 is a code of fixed length and the remainder a code of variable length.

In consequence, the entire railway system must be divided into sections of line with different route numbers, just as a network of roads is numbered. A motor car may run, say, on Road No.7, passing over to Road No. 9 and thence to Road No. 2 etc., the difference being that overtaking can take place without special arrangements.

Fig. 5 shows an arbitrarily conceived network on which some route numbers are shown, e.g. Routes Nos. 35, 22, 47, 72 etc. There are therefore several route numbers converging on a given junction, but these numbers must not be identical.

A train, carrying the number 363, may, for example depart from A = 35.03. From the routing code storage device 35.03, the train receives the routing order 363/1/35, 05/1.1. The signalling installation at 35.03 establishes for train 363 first of all, the route via the through road No. 1 (Code 1) corresponding to route 35.03 and subsequently the route direction 35 as far

as junction 05, without deviating from the through road at intermediate stations. The train then passes through junction 35.04 on the through road. At junction 35.05, the routing code storage device bestows on the train the new ZLN 363/1/22.04/1.1. Here, the train passes directly via the platform road or through road corresponding to section 22.04 and continues without deviation to junction 22.04. With the new ZLN 363/3/22.06/1.1, the train is routed to junction 22.06 but so that it uses loop road No. 3 when passing through junction 22.04.

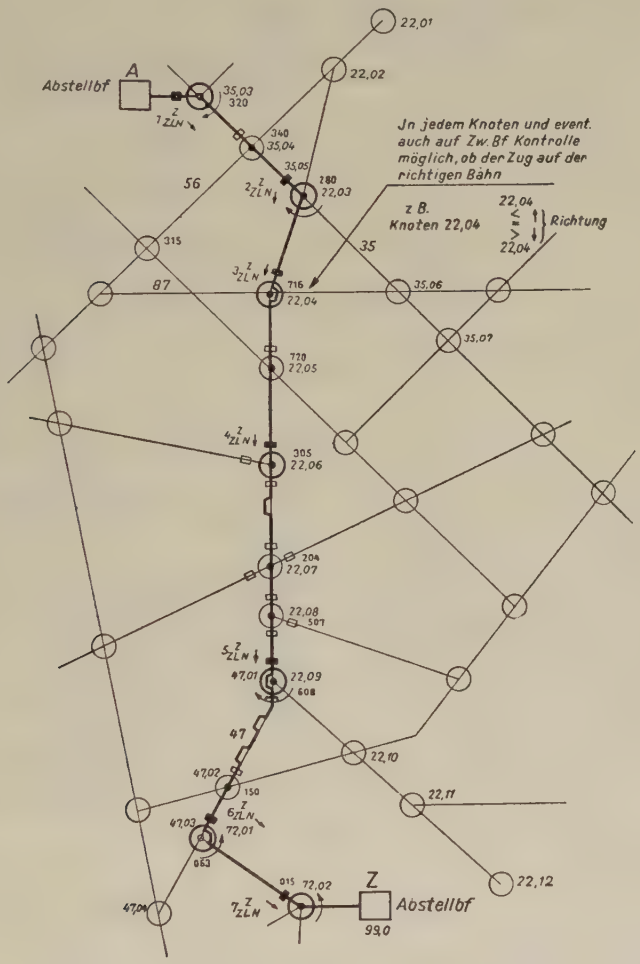


Fig. 5. — Part of railway network with train routing code stores.

Explanations of German terms :

In jedem Knoten... = It is possible to verify at every junction, and possibly even at intermediate stations, whether the train is running on the correct route. Z.B. Knoten 22,04 = for instance, junction 22,04. — Richtung = direction. — Abstellbf. = carriage sidings.

The routing code storage device at junction 22.06 directs the train under the code 363/1/22.09/1.3, to junction 22.09, after it has used loop road No. 3 at the intermediate station .

From the ZLN storage device at 22.09, the train receives a view routing order 363/4/47.03/1.3/2.4. Here, train 363 again changes to another line (Route 47), following it to junction 03, having used platform road No. 4 at junction 22.09 and loop roads Nos. 3 and 4 the intermediate stations 1 and 2, respectively.

The routing order received from the ZLN storage device at 47.03 is 363/3/72.02/1.1, i.e. the train uses Route 72 as far as 02, and passes to junction 74.01 via No. 3 road without using any loop roads at intermediate stations.

Finally, the train arrives at the carriage sidings of its destination, with ZLN 363/1/99.00.

Table 1 below shows all the ZLN codes for the whole trip of train Z = 363 in the example given above.

It is of course also conceivable to add to the train number the complete routing programme of that train over the entire trip. In that case, however, it would be necessary to transmit so many and so different codes that this proposition must be ruled out in practice. With this method, there converge at an important junction numerous lines with their junction number so that this junction itself might be given a kind of collective code number which would then however, have nothing to do with the route number of the line. These collective code numbers might also be used in a way somewhat akin to the way in which they are used in a telecommunication system. But this has a serious drawback inasmuch as it would then be necessary to take into account all the lines radiating from this junction with all the junction routing code storage devices connected to them, in order to ascertain whether the train is still on the right line. This is much simpler with the procedure described above as it is easy to verify at the ZLN storage device if, even for remote destinations, one is still following the route number carried by the code. The numbers such as 22.09 higher than that of the junction in question (e.g. 22.05) indicate one direction, and the lower numbers, e.g. 22.03, the opposite direction. There should however be no objection to using, for economic reasons, one joint routing code storage device (ZLN recorder) for several junctions.

With the aid of order stores, here used as storage devices for routing orders (ZLN), installed at the junctions, the trains can thus easily be routed automatically from section to section by always allocating to them a sequence of systematically arranged code numbers which consist of a fixed component for the station road of the first ZLN recorder ahead, and of a series of code numbers varying with the number of overtakings at intermediate stations, i.e. $Z/\ddot{U}K/Kn + m/\Sigma\ \ddot{U}S$. It

At ZLN storage device	Z (train numbers)		ZLN			
	Special number	Working numbers	ÜK	Scheduled stop yes = 1, no = 0	$Kn + m$	ÜS (intermediate stations)
35,03	—	363	1	0	35,05	1,1
35,05	—	363	1	0	22,04	1,1
22,04	—	363	3	1	22,06	1,1
22,06	—	363	1	0	22,09	1,3
22,09	—	363	4	0	47,03	1,3/2,4
47,03	—	363	3	1	72,02	1,1
72,02	—	363	3	0	74,01	—

Fig. 6. — Network of the German Federal Railways, with train routing codes for some of the most important lines.

Explanations of German terms :

Es sind nur als Beispiel... = train routing codes are only shown against the arbitrarily selected lines 0,1, 02 and 03 with their intermediate junctions 01 to 15. — Strecke = route. — Teilknoten = intermediate junctions.

is desirable to add another code number after ÜK in order to indicate that the train has a scheduled stop at the platform road, the departure being governed by the scheduled time or by the order of the local official in charge.

The indications relating to intermediate stations can be further simplified by using a more comprehensive coding system.

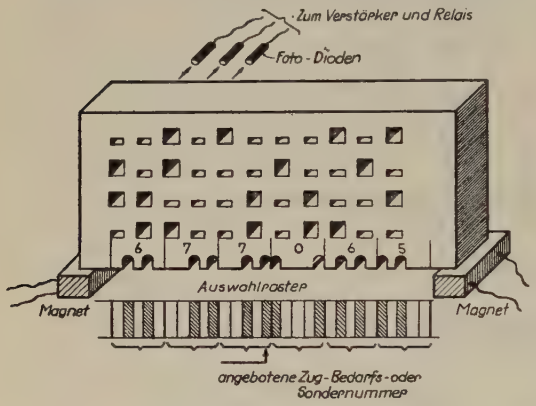


Fig. 7. — *Card Translator* used as train routing code store.

The following items of information are shown by way of example, in ± coding on the punched card illustrated in figure 7.

K*n* = junction 02, 12. — K*n* + *m* = junction 02, 17. — ÜK (loop road, e.g. platform road, at junction) 3, alternative road 4. — ÜS (loop road 5, at intermediate station 1, etc.) 1,5, 2,3, 4,2, etc. — Scheduled arrival time 12.04 p.m. — Scheduled departure time 12.14 p.m. — Loudspeaker announcement 26, etc. — Zum Verstärken und Relais = to amplifier and relay. — Auswahlroster = selection roster. — Angebotene Zug-, Bedarfs- oder Sondernummer = train number, optional path number or special number offered.

As the procedure shows, it is possible for a large railway network with numerous trains to be controlled automatically. But the control official can, at any time, remove one link of the chain, i.e. route the train at will, without prejudice to the remainder of the normal working of the train. Because of the definition of the through roads, the ZLN storage devices need therefore only record the deviations from the through road, a fact which has a very favourable influence on their size. The map, fig. 6, showing the most important and most heavily trafficated lines of the German Federal Railways, gives a clear idea of the system. It goes without saying that one can only use storage devices so designed that the stores can, at any time, easily be set up or changed.

We now propose to give a more detailed description of order stores of this type.

In such a store, all those orders are stored which can be predetermined in detail. In a sense, a timetable also represents a recorder of this type. Here, a given train (Z) is predetermined throughout its trip, in respect of time and place. To this document must be added the local operating schedules worked out for each station which also indicate the station road to be used. By itself, however, such a timetable cannot directly influence the technical apparatus. For this purpose, it would be necessary to dispose over a special device, capable of reading and acting on the instructions (setting up of routes etc.). This aim can be achieved by using the well-known punch cards. Every location on that card contains an item of information. It must, however,

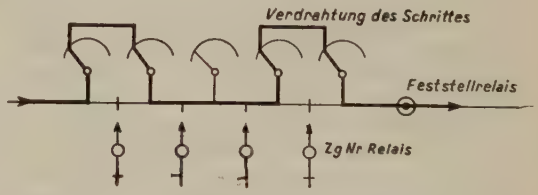


Fig. 8. — Bank-to-bank cabled selector used as train routing code store.

Explanations of German terms :

Verdrahtung des Schrittes = step-by-step cabling. — Feststellrelais = locking relay. — Zg. Nr. Relais = train number relay.

be easy to trace this card by means of a given criterion (e.g. the train number, Z), and to monitor and transmit the information to the control apparatus.

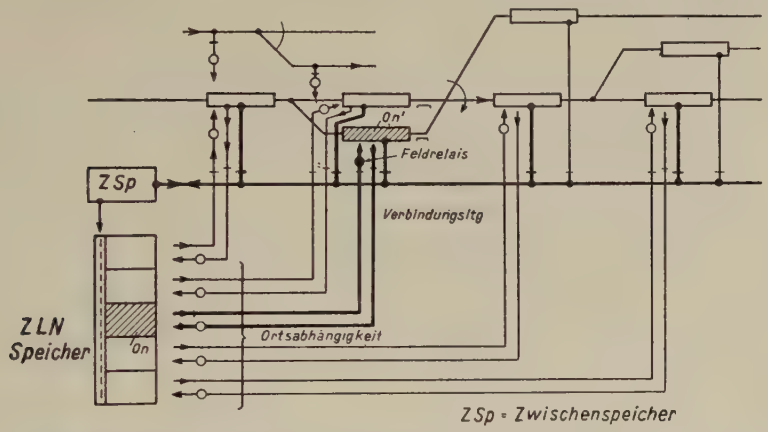
This can be achieved with adequate speed by means of a *Card Translator* (fig. 7) which has already been used successfully in the United States for setting up automatic telephone communications. The *card translator* consists essentially of a collection of 1 000 punched cards of very thin

magnet steel weighing 40 grams; each of them corresponds to a train number and must be selected for each train.

The top part contains 118 « normal holes » for the recording of programme characteristics in binary digits — +. The latter have double punch height.

given automatically to the luggage office, booking office, post office, etc.

Another possibility which is perhaps less costly where the number of items to be stored is comparatively small, consists in the use of *the selector store with bank-to-bank cabling*. (Fig. 8). This apparatus



100 magnet cards = 1 cell = 2.54 centimetres.
1 000 magnet cards = 1 box = approx. 25 centimetres.
One card contains the complete routing programme within the control zone (including remote-controlled zone).

Fig. 9. — Connections of train routing code store.

Explanations Of German terms :
Z Sp = intermediate store. — ZLN = train routing code store. — Feldrelais = field relay. — Verbindungsltg. = connecting line. — Ortsabhängigkeit = selection as a function of place.

Each card has punch holes along the edge which consists of several times seven keys 0 — 1 — 2 — 4 — 7, destined to receive the six-figure digit code of the train number.

By means of powerful magnets, the punched card concerned seeks exclusively the punch holes of normal height in the other cards. During this process bundles of light pass through the enlarged holes which are not covered up so that the light falls on germanium transistors which operate relays. The transmission, i.e. the reading of the programme, requires a time of some 100 milli-seconds. There is, on the card, enough space for other items of information such as the arrival and departure times, the selection of automatic loudspeaker announcements, the information to be

receives, through relays, the indication of the train number, and the numerous parallel selector arms follow up to that point where the bank-to-bank cabling forms the complement to the cabling of the selector arms so that a continuous circuit is formed and a locking relay is operated by the current then flowing.

In the train number position thus found it is then possible to read off all the necessary control criteria of the routing code (ZLN) for the setting up of the routes, the loudspeaker announcements etc., by means of other selector arms. This method may however be inferior to others because of the work involved in modifying the cabling.

A further possibility of order storage seems to be available in the form of the

rotating magnetic drum which is now in the course of development. A drum covered by a wide magnetophone band and possessing a very high storage capacity of, e.g. 250 000 Bit (i.e. $\pm$ values) rotates at the rate of 2 to 3 000 r.p.m. Numerous tape readers, placed close to each other, ensure ultra-rapid recording and reading

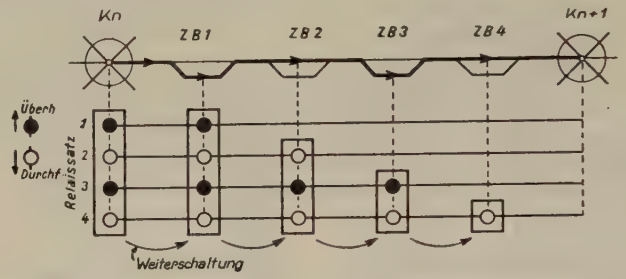


Fig. 10. — Set of relays used as train routing code store.

Explanations of German terms :

Überh. = overtaking. — Durchf. = running through. — Weiterschaltung = order transmission.

without mobile parts. With this device, the recordings of train routing codes (ZLN) can be easily modified.

Fig. 9 shows how the train number indication is transmitted through a joint multi-wire connection, by operation of the corresponding field relay, to an intermediate store which enquires from the order store the new train routing code (ZLN). In addition, however, it is also necessary to select, in the ZLN store, the place (O*n*) which corresponds to the place (O*n*) of the train number (Z) in the track layout. From each place (O*n*), a selector line connects with the corresponding zone O*n* on the punched card. At the same time, there is a return connection to O*n* transmitting the control criteria, i.e. the train routing code which governs the setting up of the route.

At the intermediate stations, the sequences of code numbers, e.g. 2.3/5.4, only control the setting up of the route via the through road or the loop roads. As already mentioned, this method of transmission probably calls for expensive installations. It would therefore seem that another method, similar to the method of controlling routes on the hump of a marshalling yard, may be simpler. In fact, it is only necessary to distinguish between through road and loop road.

In this case, each intermediate station is equipped with a set of relays (fig. 10). The programme (through road or loop road) corresponds to the position of relays 1 to *n* (in our example : 1 to 4, where — signifies the loop road and + the through road). The relay position, derived from the train routing code store at the junction, here — + — +, is transmitted to the

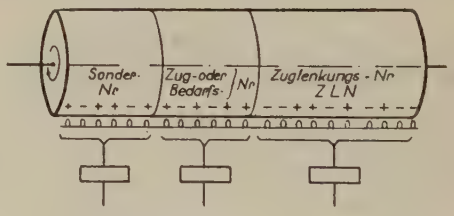


Fig. 11. — Information storage drum used as train routing code store.

Explanations of German terms :

Sonder Nr. = special number. — Zug- oder Bedarfs-Nr. = train number, or number of optional path. — Zuglenkungs-Nr. (ZLN) = train routing code.

line together with the train number and the routing code integrated with it, as far as the first station. At station 1, relay1 operates the points (— for the loop road). The positions of the remaining relays, 2 +,

3 —, 4 +, are similarly transmitted to station 2 where, because of the indication 2 +, the through route is set up. The remaining orders, 3 —, 4 +, are passed on to station 3, and relay 3 — sets up the route via the loop road. The order 4 +, eventually received at station 4, causes the setting up of the through road at that station. The train number is passed on to junction K*n* + *m*. At that junction, the only orders received are Z and the part K*n* + *m* of the train routing code (ZLN). At junction K*n* + *m*, the operation begins afresh with the aid of the train routing code store at that point.

If there are several loop roads at the intermediate stations, two relays would be used for each station which would permit the setting up of as many as four different loop roads, corresponding to the four combinations of the station relay set : ++, +—, —+, ——.

In conclusion, this is just a first glimpse to show how, with the means at present at our disposal, it is possible to introduce wholly automatic routing of trains for railway networks of any size.

As already mentioned, the method can also be applied to goods trains. For regular trains and merely optional trains, the train number is fixed and can, as in the case of passenger trains, be coupled with the routing code.

Particular features will only arise in the case of goods trains carrying a special number. In this case the special number corresponds to different optional paths throughout the trip of the train. As the optional paths are given train routing codes (ZLN) stored at the different junctions, it is necessary to match in advance by manual recording, the special number received by the train dispatch telegram with the number of the appropriate optional path. In this way, the special number is also paired with the appropriate train routing code (fig. 11) so that the freight traffic, although more individual in character, can also be treated in the same way.

By similar means, though no doubt under greater difficulties, it should in principle also be possible to cover normal shunting operations. For this purpose, it would probably be necessary to use computers which determine at any time, on the basis of the momentary operating position, the most appropriate train or shunting movement to follow, the computation being based on the momentary position of the trains and strings of wagons related to the scheduled working, on the different speeds, blocking times, waiting time instructions etc.

In practice, however, the realisation of such a difficult task progresses so slowly, in view of the necessary capital investments, that there should be no transition difficulties, the main purpose being to facilitate the task of the control official.

To-day, the ideas set out above are no doubt often regarded as utopian or at least premature. But the railways, in particular, cannot remain inactive in view of the enormous advances in modern order transmission techniques which have already been adopted, to an amazing extent, by air line companies and forwarding agents.

[625 .13 (44)]

The reconstruction of La Voulte viaduct,

by M. Maury,
Ingénieur en Chef, Chef de la Division Voies et Travaux de la Région Méditerranée de la S.N.C.F.,
and M. Carpentier,
Ingénieur Principal à la Division des Ouvrages d'Art de la Direction des Installations Fixes de la S.N.C.F.
(*Revue Générale des Chemins de fer*, January 1956.)

Between Lyons and the Mediterranean, the S.N.C.F. has two independent double track lines one on each side of the Rhône from Lyons to Tarascon.

Exchanges between these lines take place through the railway junction at Lyons and five cross lines linking up respectively :

— Chasse-sur-Rhône to Givors — Saint-Rambert-d'Albon to Peyraud — Livron to La Voulte — Avignon to Pont d'Avignon — Tarascon to Nîmes via Beaucaire (see the map, fig. 2).

These cross lines run across the Rhône on important bridges which were all destroyed or seriously damaged during the 1939-45 war.

The following note gives details of the steps taken to rebuild the La Voulte viaduct which crosses the Rhône between the stations of Livron and La Voulte (1).

Fig. 1. — View of the old bridge (fifth arch).

(1) N. D. C. R. — This note, which is mainly descriptive, gives no calculations nor any of the numerous measurements to which the completed bridge was subjected apart from a few results. A very detailed article is to be published in the review *Travaux* shortly.

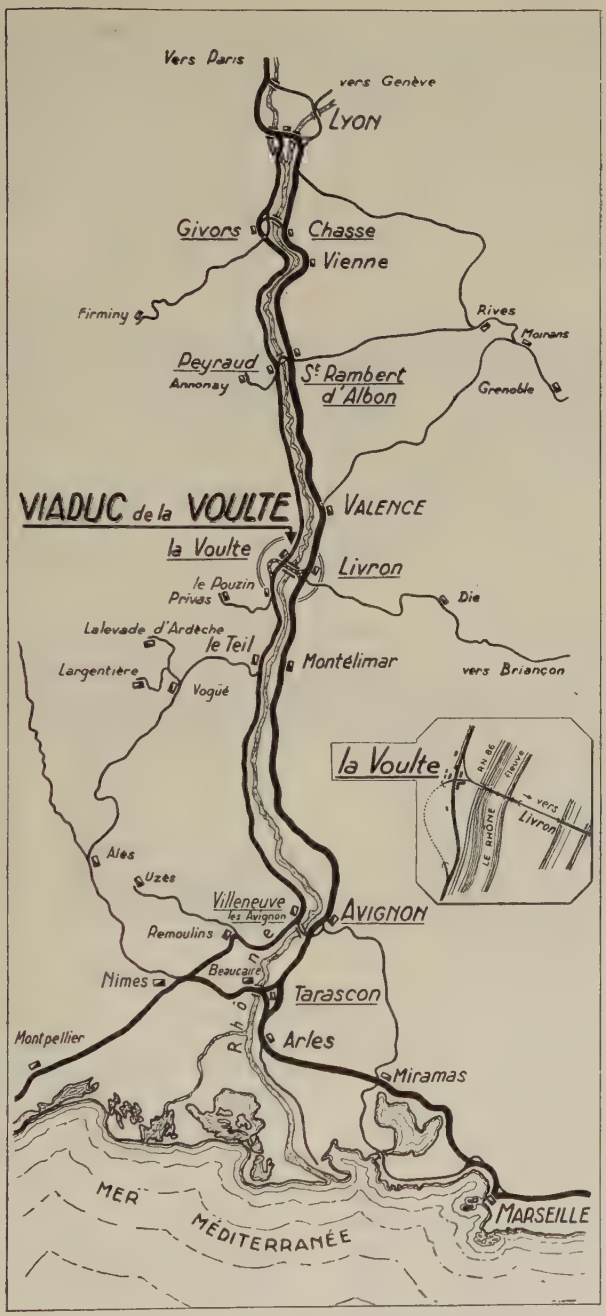


Fig. 2. — The railway lines of the Rhône valley.

HISTORY.

The original bridge, built in 1861, consisted of five cast iron arches of 55.60 m (60.80 yards) span, segmental to about 1/11th built on masonry piles and abutments. (fig. 1).

The abutment on the La Voulte side was opened out to allow the Route Nationale (R.N.) No. 86 from Lyons to Nîmes to pass through.

Owing to the increase in the rolling loads, during 1923 the spans of the viaduct were reinforced and cased in by means of a reinforced concrete reddering.

This was the first example of the association « iron concrete » suggested and perfected by M. de Boulongne, chief engineer of the P.L.M. Railway Company.

In August 1944, a bombardment by the Allies practically destroyed five arches of the viaduct and piers 3 and 4 as well as giving piers 1 and 2 a severe shaking.

The reconstruction of the piers, undertaken during 1948-49 consisted essentially of remaking by means of caissons the foundations of piers 3 and 4, and then their reconstruction up to 1.2 m (3.93 ft.) above the low water mark.

The masonry that had been loosened was reconsolidated.

As there where more urgent tasks requiring attention, the reconstruction of the viaduct was deferred until the year 1952.

Moreover, the reconstruction of the Tarascon (1947), Pont d'Avignon (1948), Chasse (1950) (1) viaducts and the restoration of the Peyraud viaduct (1951) made it possible to deal with the traffic requirements of the time (fig. 2).

GENERAL ARRANGEMENT OF THE WORK.

Various solutions for the new bridge were considered and it was finally decided to make a reinforced concrete viaduct of five identical spans, each of which was to consist of two arched girders, the permanent way laid on ballast on a bed being suspended therefrom (fig. 3).

The Route Nationale No. 86 was crossed by a separate reinforced concrete bridge.

The work was entrusted to the firm of Messrs Boussiron.

This firm, wishing to avoid the hazards of making five large arches above the Rhône for the spans, suggested an alternative : five 56 m (183.72 ft.) spans in reinforced concrete carrying directly the track on ballast. A reinforced concrete bridge over R.N. 86 was retained as in the initial project (fig. 4).

The S.N.C.F. decided to adopt this alternative provided prestressed concrete was used to avoid any risk of cracks occurring on the bridge which lying across the Rhône consequently would be difficult to maintain.

The firm agreed to make a viaduct on these lines for practically the same cost as the original project, because of its advantages :

1) the prestressing device used suppresses *entirely* all tension in the concrete;

2) the portal type of bridge makes it possible to reduce the value of the thrusts and brings these down to a lower level on the piers, the stability of which is thereby improved;

3) the reduced thickness, compatible both with the level of the rail and the clearance required for navigation, produce a bridge whose continuity of line and restrained aspect are much more satisfactory than that of a bridge with lateral girders;

4) finally, it was possible to build the spans by successive stages, without having to use forms or scaffolding blocking the bed of the Rhône.

The special features of this construction are described later on.

* * *

(1) See *R. G. C. F.*, Feb. 1951, a note by M. François on « The reconstruction of the Mediterranean viaduct over the Rhône ».

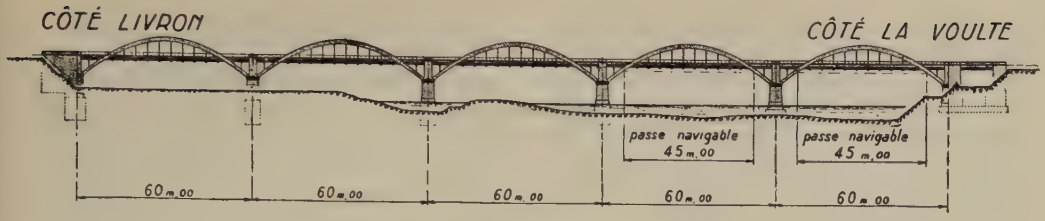


Fig. 3. — Initial proposal.

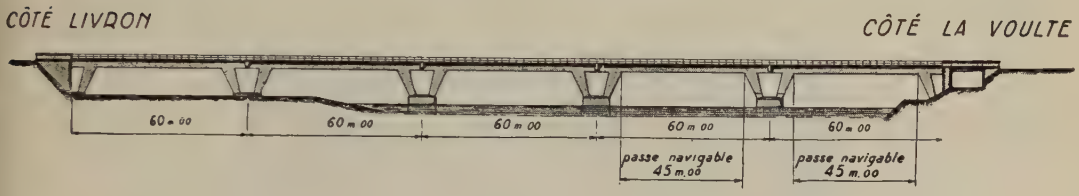


Fig. 4. — Diagram of the new bridge.

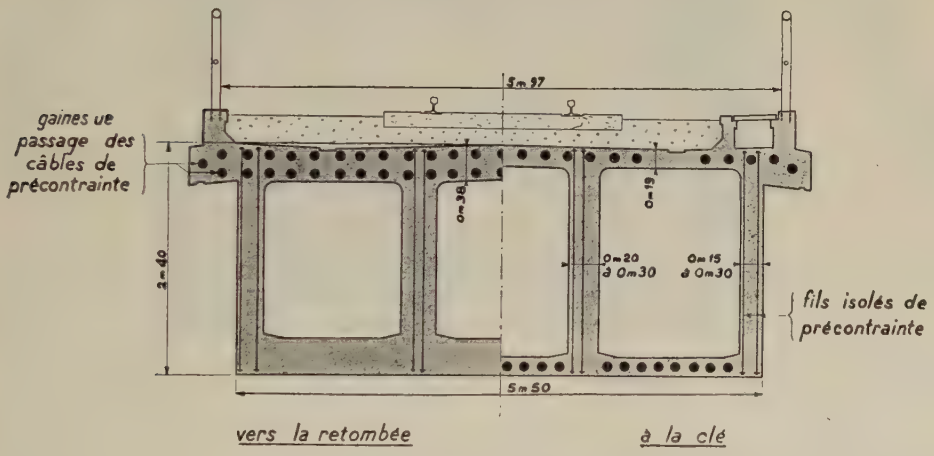

5 m. 97
gaines de passage des câbles de précontrainte
0 m. 38
0 m. 19
0 m. 20 à 0 m. 30
0 m. 15 à 0 m. 30
3 m. 40
fils isolés de précontrainte
5 m. 50
vers la retombée
à la clé

Fig. 5. — Cross section.

Explanations of French terms :
Gaines de passage des câbles de précontrainte = ducts for the prestressing cables. — Vers la retombée = at the spring. — Fils isolés de précontrainte = isolated prestressing wires. — A la clé = at the key.

ESSENTIAL CHARACTERISTICS.

The bridge was built to carry a single track line.

With its 300 m (985 ft.) total length and five 56 m portals, the viaduct of La Voulte is one of the chief prestressed concrete railway bridges.

Each portal, articulated (1) on bearers, consists of two crutches and connecting

(1) N. D. C. R. — The articulations of the spans consist of lozenges of ordinary, not reinforced, concrete 20 cm (7.87 in.) thick and 1 cm (0.39 in.) high in elevation having the same width as the crutch, i.e. 5.5 m (18.04 ft.); the tension in the concrete reaches 170 kg/cm^2.

piece. The crutches, 10 m (32.80 ft.) high are in the form of a caisson with three cavities the thickness of which in elevation varies from 1.5 m (4.92 ft.) in line with the articulation to 3.5 m (11.48 ft.) at the housing on the crosspiece (1).

This connecting member has a constant height of 2.4 m (7.84 ft.) and is similar in section to the crutch (fig. 5).

The facing of the spans are rough as they come from the shuttering.

consists of a ribbed casing 19 cm (7.48 in.) thick.

In line with the gantries, it is supported on brackets made on the outer face of the crutches.

The bridge over R.N. 86 is a bridge of ordinary reinforced concrete in one span with an opening of 11 m (36.08 ft.), 9.20 m (26.90 ft.) wide.

It consists of a 0.90 m (2.95 ft.) thick

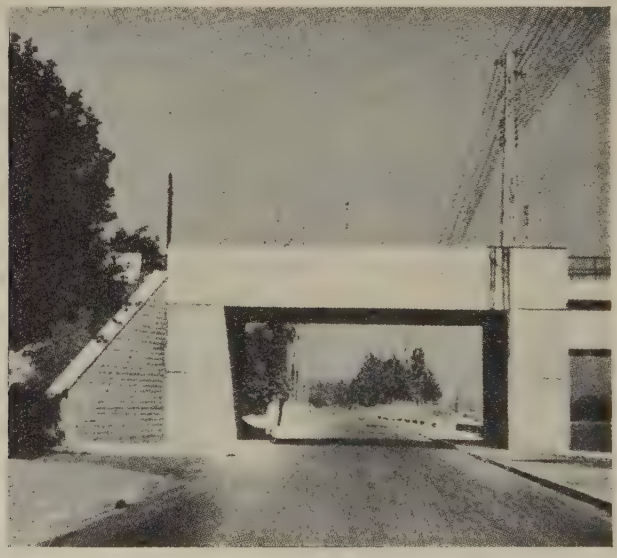


Fig. 6. — Bridge over R. N. 86.

The distance between consecutive spans on the one hand, between the end spans and the supports on the bank on the other is covered by independent decking the span of which varies from 4.46 m to 8.36 m (16.40 ft. to 28.40 ft.).

This decking, in reinforced concrete deck; two side beams, independent of the deck, 2.5 m (8.2 ft.) high, also made of reinforced concrete, give it a modern outline which harmonises with that of the spans. The facings are hammer dressed (fig. 6).

The distance between the handrails has been fixed at 5.97 m (19.60 ft.) over the whole length of the spans; it is 8.2 m (26.8 ft.) in line with the bridge over R.N. 86 so as to make it possible to add a connecting road at a later date.

* * *

(1) N. D. C. R. — Consisting in fact of a straight beam of constant height tailed into its supports, the term « cross-piece » may seem surprising in this context; it is considered by the builders as the usual practice in designing the centre part of a portal bridge.

CALCULATIONS. DISTRIBUTION OF THE PRESTRESSING CABLES.

The new bridge has been calculated to support the typical train with 25 t axle load as defined in the circular of the 14th Oct. 1944.

The ministerial circular giving provisional instructions for the use of prestressed concrete having not yet been published at the time the order was given, was not taken into account. However, special regulations were imposed, containing certain essential clauses of these instructions which were then in preparation.

crutches) led to the use of considerable prestressing values (4 160 t in the connecting piece).

The question of the space taken up by the cables then arose and to solve this, the company suggested adopting 80 t cables (1).

The distribution of the longitudinal prestressing cables based on the moments borne (fig. 7) is as follows :

— *in the crutches*, in each case : 34 cables in two parallel banks, one of 20 and the other 14 cables;

— *in the connecting pieces* :

upper decking : in each half span : 52 cables

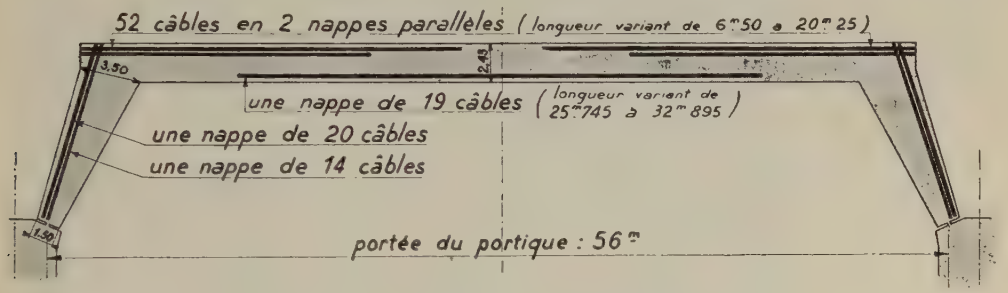

52 câbles en 2 nappes parallèles (longueur variant de 6m50 à 20m25)
3.50
2.43
une nappe de 19 câbles (longueur variant de 25m745 à 32m895)
une nappe de 20 câbles
une nappe de 14 câbles
1.50
portée du portique : 56m

Fig. 7. — Distribution of the prestressing cables.

Explanations of French terms :

52 câbles en 2 nappes parallèles... = 52 cables in 2 parallel banks (length varying from 6.50 m to 20.25 m). — Une nappe de 19 câbles... = a bank of 19 cables (length varying from 25.745 m to 32.895 m). — Une nappe de 20 câbles = a bank of 20 cables. — Une nappe de 14 câbles = a bank of 14 cables. — Portée du portique : 56 m = span : 56m.

In particular, the minimum compression stress on a fibre was taken as equal to 8 % at least of the maximum stress on this fibre.

The extreme principal tension stress must remain less than 5 kg/cm² under all cumulated stresses and the ratio of the extreme principal stresses must remain higher than $(1/0.28)^2$.

Finally, it may be added that it was not stipulated that the decking under the ballast should be prestressed in the direction perpendicular to the track. In this direction, it is made like ordinary decking in reinforced concrete.

The conditions imposed to determine the beams of the portals (connecting pieces and

in two parallel banks of 25 cables each with in addition 2 cables outside these banks;

lower decking : over the whole span : 19 cables in a single bank, and in addition four additional ducts reserved for other cables that might possibly be needed.

The total number of longitudinal cables in a portal is 191.

In order to get the best possible conditions, the longitudinal cables are straight. As a result, they do not directly reduce the

(1) It may be recalled that the prestressing cables used in the Freyssinet system are 20 to 40 t at the most.

important shear stresses borne by the portals near the supports.

The conditions laid down for the main tensile stresses and the ratio of the extreme stresses have therefore led to arrangements for completing the longitudinal prestressing described above by a vertical prestressing obtained by means of isolated wires stretched in the internal walls of the caissons.

* * *

the periphery of the cable and four in the central portion.

These wires, anchored at one end in the concrete, were to be fastened at the other end to a movable head made up of two parts, the one acting on the peripherical wires and the other consisting of a threaded shank catching the central wires, all the wires being held by buttons upset by the Swiss BBRV method.

Fig. 8. — Metal ducts.

PRESTRESSING DEVICES.

a) **Longitudinal prestressing.**

As we have said, the longitudinal prestressing cables have to be capable of exerting a force of 80 t.

Originally the cables were to consist of 16 wires of 8 mm dia. in special rolled steel, with an elastic limit of 125 kg/mm² (conventional limit to 0.2 %) and a breaking strength of 140 kg/mm².

Twelve wires were arranged around

The peripherical wires were to be put under stress by helicoidal deviation by means of a special turning screw, whereas the central wires were to be stretched by the direct traction on the central shank, which could be stopped by a screw bearing upon the turning head.

The perfecting of this process was a long and delicate job. To avoid excessive loss of time in arranging the trials in the shop, only 24 cables, in the upper decking of span 4 from the Livron side were

put under stress by helicoidal deviation.

All the other cables (i.e. 931) were stretched by direct traction. They included a movable head in one piece on which the 16 wires were buttoned, these wires being arranged in the same fashion. In the case of the cables for the lower decking, a 17th wire was added in the centre to increase the traction force to 85 t.

The cables run through metal ducts arranged in the concrete when it is poured. (fig. 8).

The fixed anchorage is obtained at one end by buttoning the wires onto a metal plate (fig. 9); at the other end, the movable

Fig. 9. — Fixed anchoring of the cables.

Explanations of French terms :

Gaine étanche = impervious duct. — 16 fils ⌀ 8 mm = 16 wires 8 mm diam. — Frette d'ancrage = anchoring ferrule. — Plaque d'ancrage = anchoring plate. — Têtes boutonnées = buttoned heads. — Tubes d'injection = injection pipe.

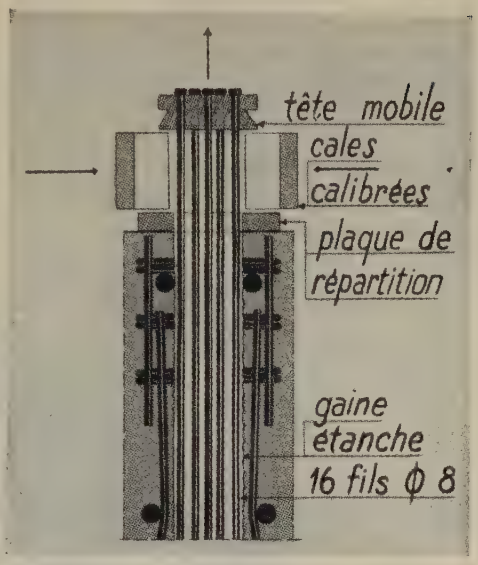


Fig. 10. — Movable head of cables.

Explanations of French terms :

Tête mobile = movable head. — Cales calibrées = calibrated wedges. — Plaque de répartition = bearing plate. — Gaine étanche = impervious duct. — 16 fils ⌀ 8 mm = 16 wires 8 mm diam.

heads bear upon the concrete by means of calibrated wedges and steel bearing plates (fig. 10).

The stress required to obtain the prestressing value of 80 t for the cables in the crutches and the upper decking of the cross pieces and of 85 t for the cables in the lower decking corresponds to an initial tension in the steel of 100 kg/mm². The fact that the elongation of the shortest cables amounts to several centimetres means that possible differences of 2 or 3 mm in the length of the different wires of a cable before being put under tension is of no importance.

The tension of 80 or 85 t was fixed after taking into account the losses due to the flowing of the concrete, the relaxation of the steel, the shrinkage of the concrete and the rubbing of the wires in their ducts. Finally, the tension of the steel must not fall below 85 kg/m² after several years, corresponding to a stress of 68 t per cable.

After the cables have been put under tension the ducts are injected with cement mortar in order to protect the wires against rusting and to assure their liaison with the covering.

b) **Vertical prestressing.**

Vertical prestressing is assured by a double row of steel wires, 7 or 8 mm in diameter, sunk into each of the vertical walls of the portal.

The fixed part consists of a head fastened to an anchoring washer.

The movable part consists of a buttoned head and a threaded sleeve making it possible to put the wire under tension by means of a screw; metal plates acting as wedges are put between the head and the concrete after the wires have been put under tension.

To prevent the steel-concrete adhesion detracting from the desired effect, each wire is first of all coated with a bituminous product called « spramex «. The resulting lack of adhesion does not affect safety of construction as the concrete does not have to support any appreciable vertical deformation.

* * *

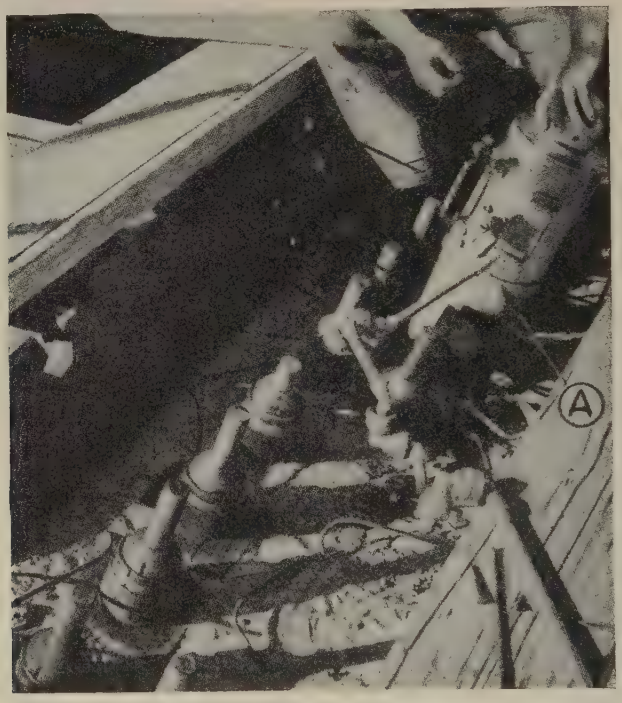


Fig. 11. — Putting the cables under tension.
(A) BBR Boussiron type screw jack.

REALISATION OF PRESTRESSING.

The putting of the cables under tension is effected by means of a 100 t traction screw jack, type BBR-Boussiron, fastened to the movable head of the cable, either directly or by means of a pair of threaded half-bearings bearing against the shoulders of the heads and capped themselves by the shank of the screw jack ending in the shape of a bell (fig. 11).

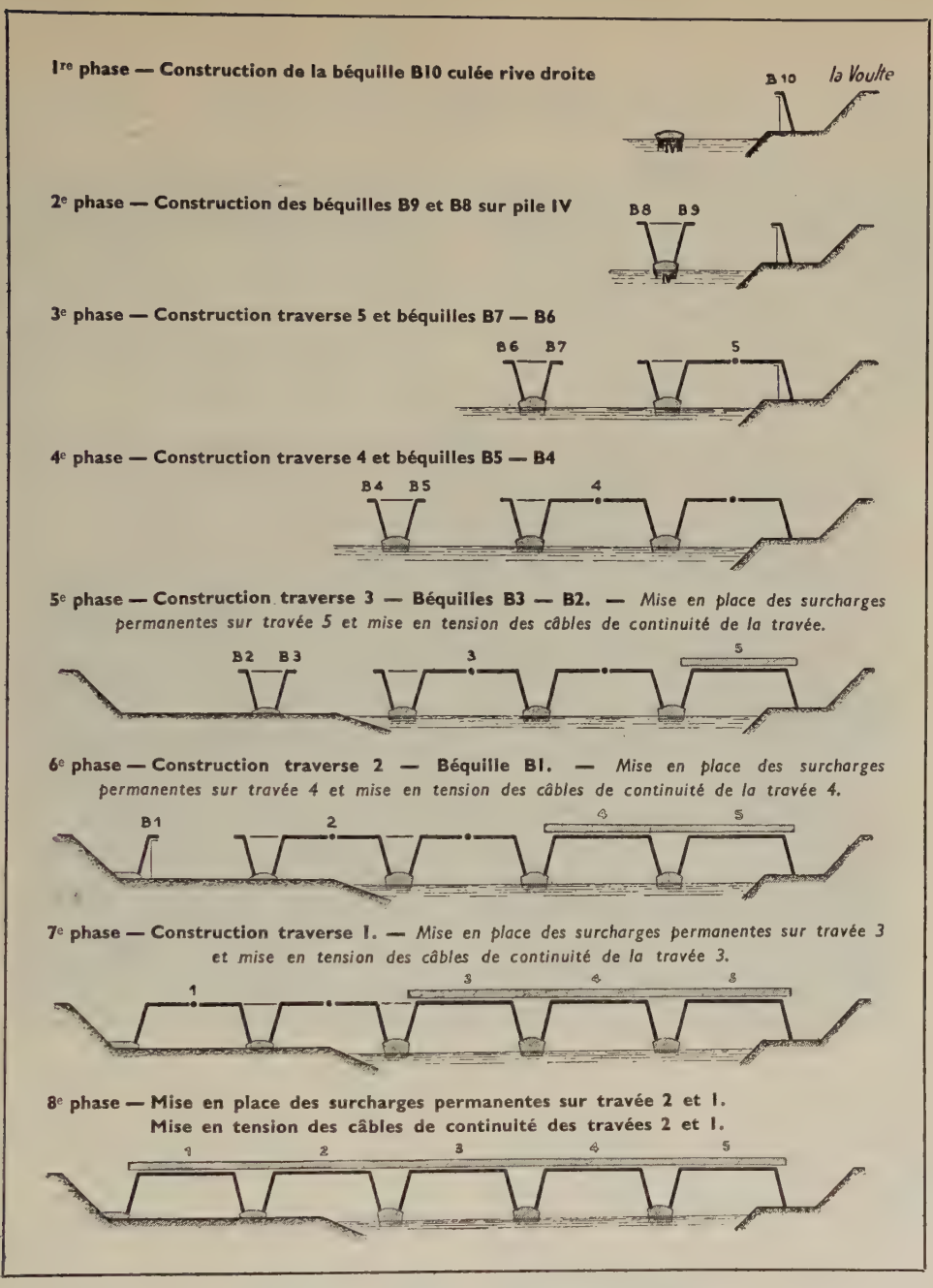

1re phase — Construction de la béquille B10 culée rive droite
B10
la Voulte
IV
2e phase — Construction des béquilles B9 et B8 sur pile IV
B8
B9
IV
3e phase — Construction traverse 5 et béquilles B7 — B6
B6
B7
5
4e phase — Construction traverse 4 et béquilles B5 — B4
B4
B5
4
5e phase — Construction traverse 3 — Béquilles B3 — B2. — Mise en place des surcharges permanentes sur travée 5 et mise en tension des câbles de continuité de la travée.
B2
B3
3
5
6e phase — Construction traverse 2 — Béquille B1. — Mise en place des surcharges permanentes sur travée 4 et mise en tension des câbles de continuité de la travée 4.
B1
2
4
5
7e phase — Construction traverse 1. — Mise en place des surcharges permanentes sur travée 3 et mise en tension des câbles de continuité de la travée 3.
1
3
4
5
8e phase — Mise en place des surcharges permanentes sur travée 2 et 1.
Mise en tension des câbles de continuité des travées 2 et 1.
1
2
3
4
5

Fig. 12. — Phases in carrying out the work.

Explanations of French terms (from top to botton).

1st phase — Construction of the B10 crutch abutment right bank.
2nd phase — Construction of crutches B9 and B8 on pile IV.
3rd phase — Construction of connecting piece 5 and crutches B7 and B6.
4th phase — Construction of connecting piece 4 and crutches B5 and B4.
5th phase — Construction of connecting piece 3. — Crutches B3 and B2. — *Introduction of permanent load on span 5 and putting the continuity cables of the span under tension.*
6th phase — Construction of connecting piece 2. — Crutch B1. — *Introduction of permanent load on span 4 and putting the continuity cables of span 4 under tension.*
7th phase — Construction of connecting piece 1. — *Introduction of permanent load on span 3 and putting the continuity cables of span 3 under tension.*
8th phase — Introduction of permanent load on spans 2 and 1. — Putting the continuity cables of spans 2 and 1 under tension.

Putting under stress takes place in stages of 50 kg/cm² of pressure read at the gauge on the screw jack; the control of the elongation is effected by means of a graduated rule between two determined points, taken one on the body of the screw jack, the other on the traction shank. The elongations correspond to the variations in this reading.

In the case of the few cables put under stress by helicoidal deviation, the value of the tension obtained is determined by the number of turns given to the screw jack, by comparing the values measured on a sample standard cable with similar characteristics.

As will be seen in the Chapter « Carrying out the work » a certain number of cables played the part of scaffolding in carrying out the work of making the overhanging « voussoirs » (1). These cables were put under tension in two phases :

a) the first putting under tension took place after removal of falsework from the voussoir. After leaving the concrete to dry out for three days, a 50 kg/mm² traction stress was put into the cables and temporary half-bearings placed under the anchoring head, the height of which corresponds to the theoretical elongation at half-load;

b) the second stressing takes place when making the following voussoirs, according to the order given in the working programme in order to complete the prestressing as the stresses in the brackets increase.

After noting the coming away pressure of the anchoring head on the temporary half-bearings, the pressure is increased by degrees to 50 kg/mm² noting the corresponding elongations.

As soon as possible a pair of half-bearings of the same height as the theoretical elongation for the rate of 100 kg/mm² increased by 2 mm is introduced to take into account the imprint of the anchoring head and the

Fig. 13. — The service bridge.

(1) See explanation of this term later on.

initial play between the buttons and the anchoring head and between the latter and the bearing plate into account.

The possibility of putting under stress in two successive stages is a special feature of the type of cable used.

Cables, which do not take any part in the work during its execution, are put under stress when the ballast is laid, when the span is under its full permanent load.

the stresses on the bridge under the effect of the permanent loads.

We give below certain details about special features in carrying out the work.

DETAIL OF THE PHASES OF CARRYING OUT THE WORK.

The work was done in such a way as to avoid any scaffolding or centering in the bed of the Rhône.

Fig. 14. — Another view of the service bridge.

The stressing is carried out in a continuous fashion putting in temporary wedges after each last turn of the screw jack, i.e. about every 45 mm of elongation.

* * *

CARRYING OUT THE WORK.

The actual bridge was built out from the right bank of the river (La Voulte side) towards the left bank.

The spans were constructed separately, according to a definite processus, in eight main stages as described below, intended to give the minimum stress on the scaffolding, with supplementary regulation of

a) **Crutches :**

The crutches were built in sections of 1.20 m (3.93 ft.) in height, to which the name of « voussoirs » was given, by analogy with the constructional details of arched bridges; the prestressing cables were put in place and regulated before concreting began.

The mould was taken over the whole height of the crutch on three sides (intrados and sides) the extrados was carried out by means of sliding shuttering corresponding to the height of the voussoirs (1.20 m).

The making of the crutches necessarily took place before the making of the connec-

ting pieces, so that the bringing up of the materials required for the two crutches, which rest on each of the five piles which are isolated in the river, took place by means of a service bridge for which a Bailey bridge was made over the Rhône (fig. 3 and 14).

concrete had developed a resistance to compression of at least 215 kg/cm², i.e. three days after it had been laid.

The shutterings required for making these voussoirs were suspended from the Bailey bridge and moved on as the work advanced (fig. 15 and 16).

Fig. 15. — Making the voussoirs of the connecting piece in advance.

b) **Connecting pieces :**

The connecting pieces were made in stages by « voussoirs » of 2.75 m (8.96 ft.) in length each, built symmetrically in relation to the centre line of the span (1).

Before each of these voussoirs was concreted, the previous voussoir was fastened to the part already concreted by putting 4 cables under half load in order to assure its keeping in place without the joint opening up.

This stressing took place when the

To prevent the Bailey bridge from being over-loaded, it was keyed in turn on the last voussoirs constructed.

The equilibrium of the crutches and the connecting pieces under construction were obtained by means of a thrust beam suspended from the Bailey bridge. The corresponding thrust was diverted to the top of the crutches by means of screw jacks acting on temporary reinforced concrete plates fastened to the head of each crutch by means of prestressed wires (fig. 17).

The upper cables, some of which helped in the making of the overhanging voussoirs, were put into place before the concreting; those of the lower decking were put into place after concreting in the ducts left when the concrete was poured.

The shutterings for each voussoir were

(1) N. D. C. R. — The term « voussoir » has been used here owing to the analogy mentioned above, although in this case the components in question are identical parts of parallelepiped form; the section of the « key » of each « connecting piece » corresponds to the axis of the span.

put into place on the level and the tightening up of the moulds done by screw jack in order to avoid unslightly marks on the visible parts of the span.

The central voussoirs being completed, a temporary articulation was made by means of jacks in the key section. This articulation was made at the level of the average fibre of the upper decking of the connecting piece in order to reduce appreciably the very important negative stresses produced in the housing of the connecting piece on the crutches.

The filling in of the key and the putting under stress of the continuity cables (cables of the lower decking and other cables of the upper decking and the crutches) was only done after the total permanent load was established.

* * *

SUPERVISION OF THE WORK AND MATERIALS USED.

The work was carried out by the firm Boussiron, which had made the studies in collaboration with the Bridges and Fixed Installations Department of the S.N.C.F.

The work at site was directed by the Mediterranean Region.

The work site was equipped to make sure the composition of the concrete would be absolutely constant; for this purpose the aggregates were weighed; the strength of the concrete after 90 days was 500 kg/cm², as the following table shows which gives the result of tests of the concrete.

The construction of the bridge necessitated the use of 2 600 m³ (3 400 cu. yards) of concrete, 220 t of steel and 80 t of prestressing cables.

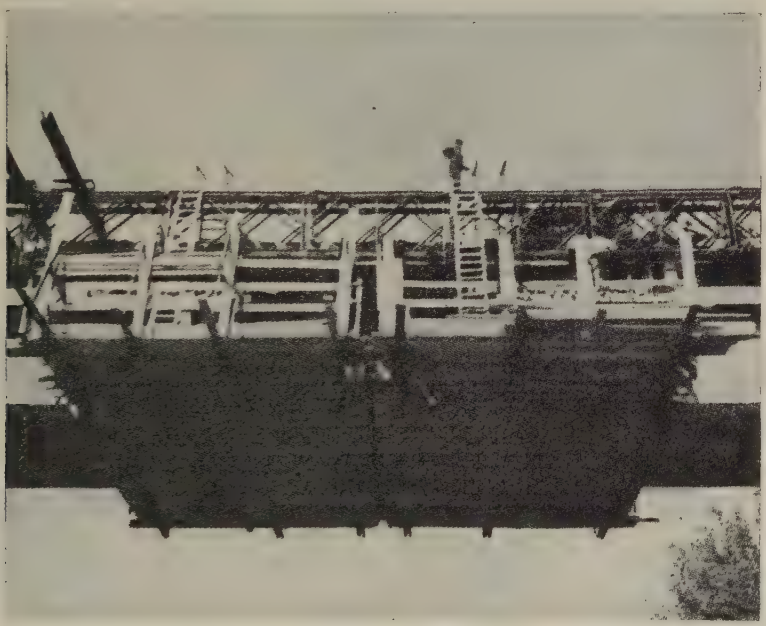


Fig. 16. — Shuttering of the central voussoirs.

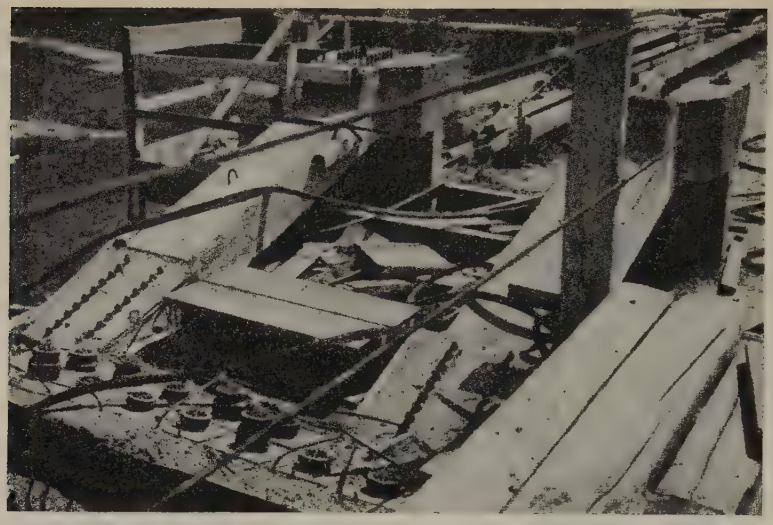


Fig. 17. — Temporary support for the thrust beam.

Fig. 18. — View of the completed bridge.

Results of tests of the concrete.

Date poured	Compression on cubes in kg/cm²			Traction SIMRUP in kg/cm²		
	7 days	28 days	90 days	7 days	28 days	90 days
17- 7-53	360	433	455	53	55	62
21- 8-53	380	490	490	46	65	68
12-11-53	292	438	485	39	61	57
15- 3-54	330	424	512	36	54	64
19 -5-54	350	463	504	32	43	69
10- 7-54	»	470	545	»	67	66
3- 9-54	327	485	528	55	63	69

TESTS.

Tests were made on the 27th September 1955 by means of a trial train made up of two 141 R engines and six Talbot couplings representing a load of 20 t per axle.

The deflections were recorded on each span under the passage of the trial train at 5, 20 and 60 km/h.

Their amplitude varied between 8 and 10 mm (0.31 and 0.39 in .) corresponding perfectly to the theoretical deflection determined by calculation (9.6 mm [0.373 in.]).

A very close inspection of the bridge after the trials revealed nothing abnormal, so that the bridge was opened to traffic (fig. 18).

Its official inauguration took place on the 4th October 1955.

This achievement is a great tribute to French technical skill.

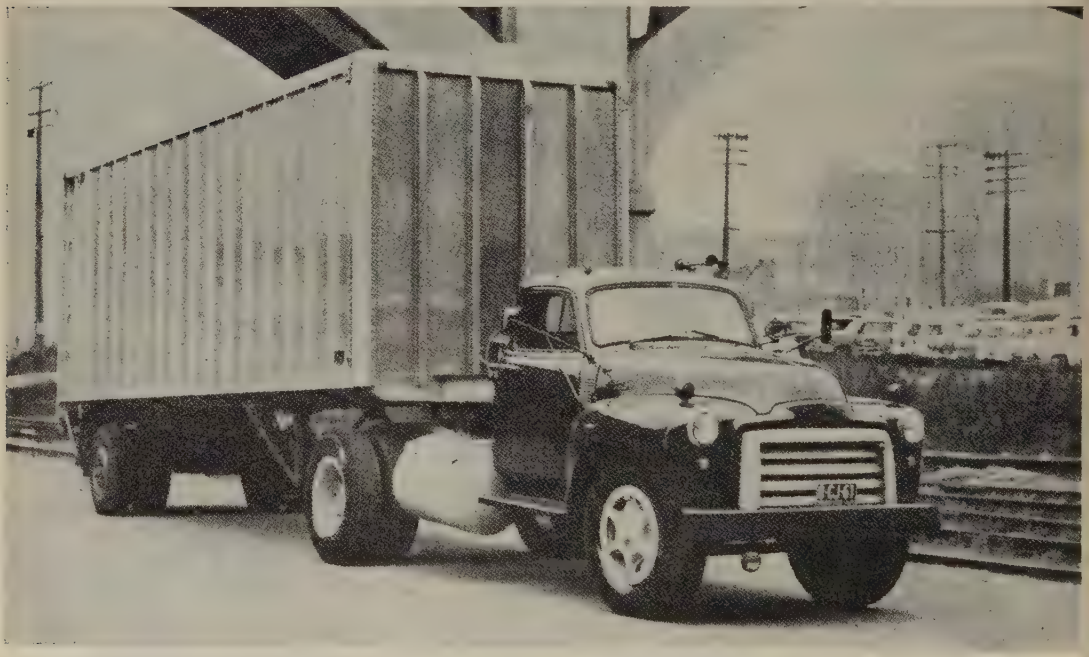
[656 .2 (73)]

« Railvan » marries road and rail.

(Railway Age, May 14, 1956.)

The Chesapeake & Ohio's « Railvan » — an hermaphrodite vehicle which runs on rails and on the highway with equal facility (*Railway Age,* February 27, p. 8) — has reached a stage of development where extensive service tests have shown that the vehicle will give freight a safe and fast ride — whether behind a highway tractor or in trains on the rails. Kenneth A. Browne, director of research, emphasizes, however, that there are a number of ideas yet to be worked out on Railvan and that the two vehicles shown publicly for the first time at the railroad's annual stockholders' meeting in Richmond, Va., on April 26, are experimental prototypes in the development.

IN TERMINAL AREAS . . .



. . . Railvan is fifth-wheeled by a conventional truck-tractor, for which service it is equipped with standard brakes and lights. On the highway, speed is limited only by legal restrictions and tractor power.

A new vehicle.

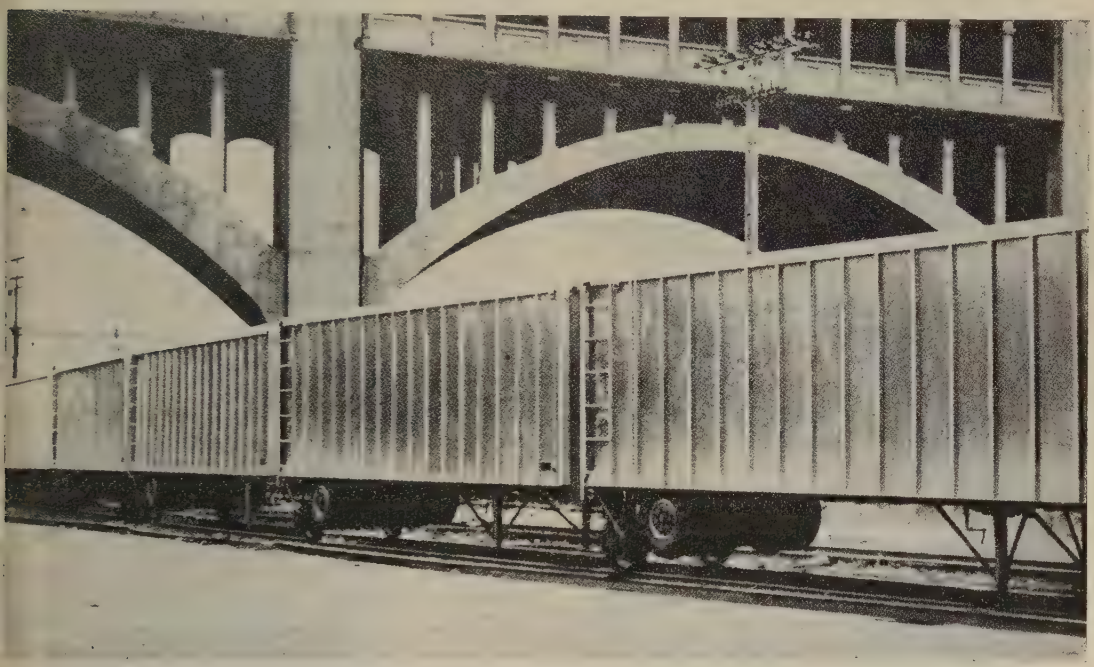
At a superficial glance, Railvan looks

like an ordinary modern highway semi-trailer with what appears to be an extra dolly hung from the body behind the highway wheels at the rear. Actually, Railvan is a completely new type of vehicle which incorporates a center sill, two bolsters, and the strength requirements of a railroad car, together with the superstructure design, fifth wheel and braking system which characterize a highway vehicle.

Economics of Railvan have been researched and developed by the C & O in the search to find a vehicle which will provide the inherent low cost of long haul by rail and the flexibility of the truck for terminal distribution.

While conventional piggyback provides the physical means of attaining these goals, it involves the movement of one vehicle atop another in transit over the railroad. In ordinary TOFC, three tons of dead weight (including the weight of the locomotive) must be carried for each ton of lading, on the average, according to the C & O. Railvan, by comparison, with a load of 7 tons, produces a tare-load ratio of 1 to 1.

FOR THE LONG PULL . .



. . . hermaphrodite vehicle couples into trains, braked by standard railroad air, and capable of conventional freight train speeds.

Unlike most hermaphrodite vehicles developed in the past for combination railway-highway service, Railvan is designed to couple in trains — up to 150 units — for economical movement on the rails.

Its designers say Railvan successfully meets the following requirements :

1) It incorporates the highway vehicle safety specifications of the ICC;

2) It has a separate set of wheels for railroad service and another for highway service;

3) It can be transferred quickly from highway to rail operation, and the reverse;

4) It has a special type coupler for movement in trains and has built into it a buff element comparable to the railroad car center sill;

5) It is equipped with a railroad air brake system operated from a conventional source;

6) It combines lightness of weight and strength of structure.

Railvan meets all ICC safety specifications with regard to highway movement — such as lights and reflectors. It has also ladders on both sides on the rear end and a running board on the roof. While these attachments do not entirely meet ICC rules for safety devices, Mr. Browne believes either that (1) Railvan can gain acceptance as a new type of vehicle justifying minor departures from standard fitments or (2) by the attachment of movable parts, end ladders and grab irons required to meet ICC standards can be provided.

In revenue service Railvan could be operated in a number of ways. The C & O thinks the general pattern of operation will comprise :

1) *pick up of the van by ordinary truck tractor from shippers' loading docks;*

2) *parking of the vans diagonally in a line along an assembly track in the railroad terminal yard;*

3) *assembly of the vans into railroad trains.*

A terminal crew — using a « spotter » or special transfer vehicle described below — hauls each van from the parking area; spots the van over the rails on the assigned outbound tracks; lowers its railroad wheels onto the track; adjusts the wheel suspension to align with the coupler on the front of the leading van; backs into it to engage the couplers; then further raises the vehicle to normal running height, whence the leading van's front dolly wheels can be retracted. The spotter then drops the last van's landing gear to the rails, disconnects, and departs for the next van.

This procedure continues for all vans in the group — building up a train from rear to front. An adapter truck is then coupled to the leading van in the train, to which a locomotive with standard couplers can be attached.

It is envisaged that Railvans would be operated in solid trains and not mixed with other equipment. Preliminary tests indicate that it would be entirely feasible to run trains of a least 150 Railvans; their strength and tracking ability would permit trains of 200 cars.

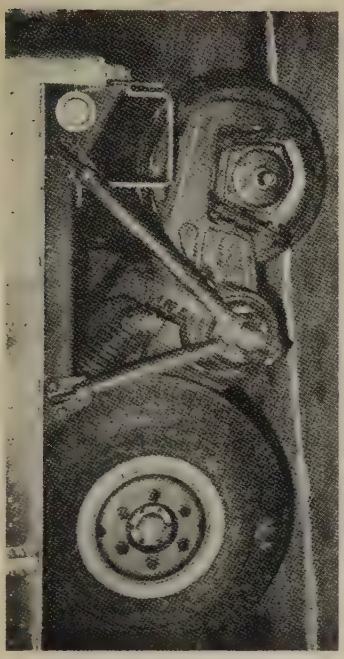
Nominal load capacity of the Railvan is 10 tons. Actually, in rail service, it will carry up to 14 tons. The real limit on load, therefore, is imposed not by the railroad service, but on the highways to comply with city and state weight regulations.

The underframe of Railvan comprises a tubular center sill on which are assembled crossbearers and front and rear bolsters. The center sill is attached to the rear coupler only and can deflect in the rest of the structure producing one

Important statistics of railvan.

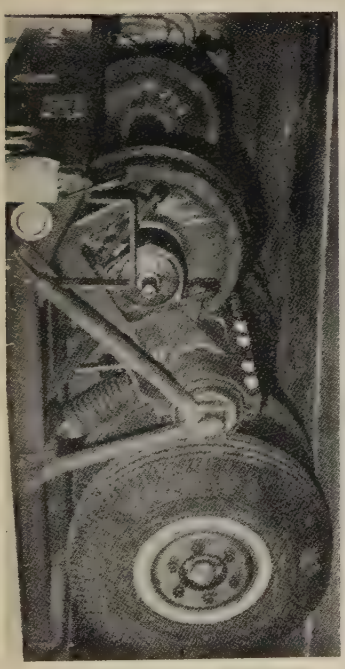
Length of body	26 ft 4 9/16 in.	
Length overall	29 ft 3 1/2 in.	
Outside width	8 ft	
Highway clearance	12 ft 3 in.	
Rail clearance	11 ft 7 in.	
Floor height		
Highway	51 in.	
Rail	43 in.	
Coupler height rail	37 5/8 in.	
Rail wheel	24 in.	
Highway wheel	10.00-15	
Weight empty	10 500 lb	
Weight loaded	38 000 lb	max.
Load capacity	27 500 lb	max.
Design tire load	22 000 lb	

FOR MOVEMENT ON RAILS . . .



By controlling length of highway and rail arms, the same spring deflection is achieved for rail as for highway operation. Air motor which changes wheels also raises or lowers body to give equal coupler height for rail movement, regardless of weight of lading.

FOR HIGHWAY SERVICE . . .



Arms supporting highway wheels (above) and railroad wheels (opposite) are attached to springs. By hanging highway arm on this spring, the railroad wheels can be moved to provide necessary clearance between the rail and the tires. It can adjust to loading dock height.

half-inch compression under buff load of 300 000 lb.

Materials for Railvan were selected to achieve high strength yet low weight. The underframe is low alloy, high-strength steel, while the body is made of aluminum-silicon-magnesium alloy. The sides use the outside stake principle for simplicity of connection to underframe. The inside skin acts both as a strength member and as an inside lining of the body. The floor, made of aluminum extrusion, is also what is described as « a sheer diaphragm ».

Railvan has two completely separate braking systems. That used in highway service is the type conventionally used in over-the-road highway tractor-trailer rigs with hose air brake and control connections between the semi-trailer and the tractor.

For movement in railroad service, Railvan is equipped with brakes working off conventional railroad train brake pressures and controls. The actual application of braking power to the rail wheels, however, is designed on a new principle by which the brakes are kept applied by a spring and released only when air pressure is built up in the train line and compresses the spring. Thus, when Railvans are on a track and left by the locomotive, they are fully braked automatically, since the normal position of the brake is « applied ». This obviates the necessity for hand brakes, which are not provided on Railvan as presently designed.

The brake cylinders, one for each wheel, are part of the brake beam, which contains a composition brake shoe and slack adjusters. The brake beam is hung from the rail arms, with the brake piston connected to the coil spring housing.

For highway service, as noted, Railvan is equipped with a conventional fifth wheel.

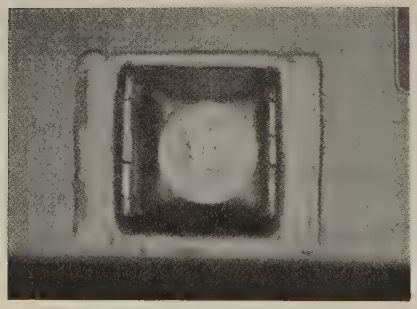
For railroad service, Railvan is equipped with a specially designed coupler of the male-female type capable of supporting the vertical load, since each van is

equipped with only one pair of wheels. The male portion of the coupler is attached to the center sill at the front of the vehicle, while the female portion is welded into the rear bolster.

The coupler is completely automatic, engaging on impact, and disengaged from

COUPLING DEVICE

Male portion of automatic coupler (above) is attached to center sill at the front of Railvan. Coupler engages on impact and is released by brakeman from side of van with conventional uncoupling lever. Female part (below) is welded into rear bolster. Center hole is part of train brake pipe system which is connected automatically when coupler engages.

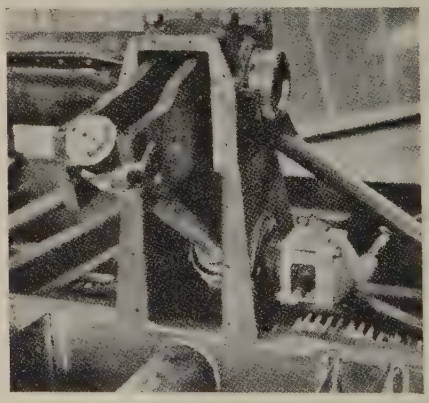


the side of the vehicle through a conventional coupling lever. The center of the coupler contains the air-brake line which is connected or unconnected automatically. In railroad running position, the coupler on Railvan rises 37 inches above the rail — 3 inches higher than standard coupler height for freight cars.

The C & O has under development a special transfer vehicle for moving Railvans between parking areas and tracks and for assembling them in trains. It picks up hydraulically the front of a van, moves it to the track, shifts the wheels from road to rail and couples up — all within two minutes. This spotter moves and spots the Railvan through the railroad coupler, rather than on the fifth wheel, and consequently automatically connects by trainline air, since the mechanism which transfers the wheels is actuated thereby. The spotter is kept coupled until the changeover has been made. Although an ordinary highway tractor can be used to transfer Railvans, yard air must be used to operate the wheel mechanism and the van's landing gear must be adjusted to allow for a difference of 14 inches between rail and highway positions.

Suspension is the real key.

« The real key to the design of the Railvan », according to the C & O's research department, « is its method of suspension ». To make Railvan practical,



To change wheels, air motor drives actuator screw through a gear train. Latter is connected through splined sleeve and arm to « torsilastic » springs.

its developers had to devise a means by which the different heights required by rail and road service could be attained simply and at the same time adjust to varying weights of lading.

The arms supporting both highway wheels and rail wheels are attached to the outer casing of a B. F. Goodrich « torsilastic » spring. This comprises a rubber tube vulcanized to an inner, stationary tube and a movable outer sleeve — thereby providing elasticity by deflection of the rubber. In this design, which provides control of the length of highway and rail arms, the same spring deflection is achieved by both highway and rail operation. Furthermore, by hinging the highway arm on the spring, the railroad wheels can be moved to provide the necessary clearance between the rail and the tires.

The inner or stationary elements of the torsilastic springs are connected through a splined sleeve and an arm to the actuator screw — driven through a gear train by an air motor.

The air motor, operating on conventional railroad 90-psi air brake pressure, « twists » the spring and transfers the van from highway to rail position or back in about 30 sec. Into the motor there is built a locking device which can fix the suspension system in any position. A scale and pointer show the operator when the van is in a proper height for coupling in rail service.

Thus the tranfer operation not only lowers and retracts the wheels, but also operates to level the vehicle, both in relation to the vans in the train in rail service and in relation to loading docks used in highway service.

The designers of Railvan faced a clearance problem — namely, to find a place to store the highway wheels when the van is in rail service. They solved it by installing 10.00-15 « Low Boy » type tires.

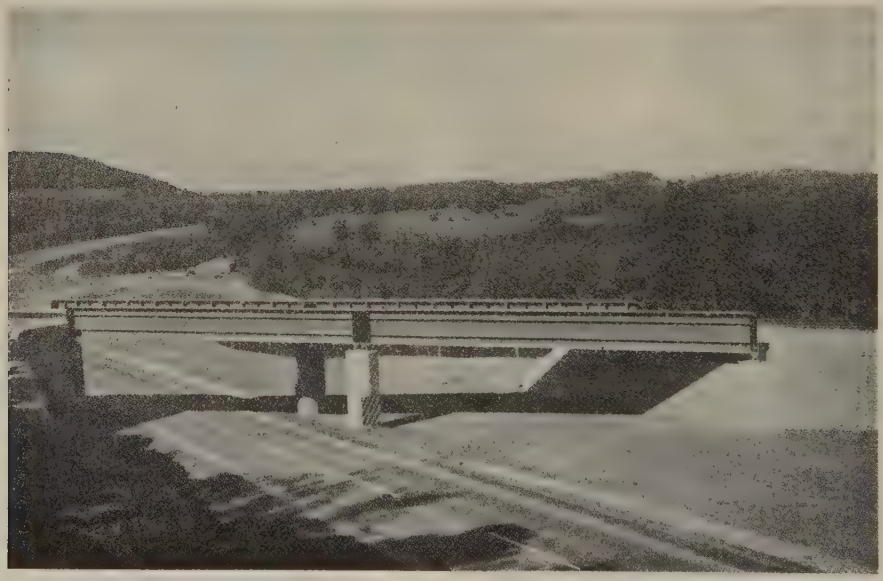
[624 .5 (73)]

All-welded underline bridge.

Through-girder single-track structure on U.S.A. branch line, with no outside vertical stiffeners.

(*The Railway Gazette*, June 15 1956.)

Though many American railways use welding for the repairs to and strengthening of underbridges, those with lines in New York State have hitherto never agreed to the construction of an all-welded structure for carrying any of their lines over highways. Now, however, the Delaware & Hudson Railroad administration has approved welded design for a new single-line bridge to carry its Cherry Valley branch over a by-pass on U. S. Route 20 round Cherry Valley village.



All-welded bridge carrying the Delaware & Hudson Railroad over the Cherry Valley Turnpike 20 in New York State; note the internal vertical stiffeners on the far girder and two horizontal stiffeners on the near one.

This bridge consists of two 80-ft. skew plate-girder half-through spans, designed to American Railway Engineering Association standards and the American Welding Society's specifications for E-60 loading. The girders are 7 ft. 5 in. deep and each comprises an 84-ft. web plate $^{5}/_{8}$ in. thick, and 20-in. flange plates varying in thickness from $1\,^{1}/_{2}$ in. to $2\,^{1}/_{2}$ in.

Absence of vertical external stiffeners.

Their outstanding feature is that they have no vertical external stiffeners, but instead, two 6 in. × $^{1}/_{2}$ in. horizontal

plates running the full length of each girder are provided as stiffeners. At the end bearings and as internal intermediate stiffeners there are, however, 9 in. × $^3/_4$ in. and 7 in. × $^1/_2$ in. vertical plates respectively.

This design using vertical stiffeners inside and horizontal stiffeners outside, provides a system stiffer than either of the two types alone. It has been shown that the stiffening effect of a single stiffener is greater than a pair on opposite sides of the web for the same weight and material involved. By the use of two horizontal stiffeners outside the web the depth of the web as a column is reduced to one-third full depth. The combination of vertical and horizontal stiffeners provides a girder much stiffer and less apt to buckle than one of conventional design. Investigation as originally carried out in 1949 when this type of stiffening was first used, is outlined in American Society of Civil Engineers Proceedings of 1941 Pt. 2, Pages 1052 to 1091 by L. Moisseff and F. Lienhard. Since that time the American Association of State Highway Officials Specifications of 1953 cover the size of longitudinal stiffeners by empirical formula as indicated in Article 3.6.81 of these specifications. The maximum vertical stiffener-spacing was found by empirical formula but the actual spacing was determined by the floor-beam spacing. The horizontal stiffeners were not designed to take any longitudinal stress; they take care of the diagonal compression. The use of horizontal stiffeners does very slightly increase the amount of steel in this particular case, but normally their use would save steel by reducing the thickness of the web plate from 1/176 D to 1/270 D. However, as this was the first all-welded railroad girder bridge in New York State, and as the American Railway Engineering Association does not specifically cover longitudinal stiffeners, it was decided to leave the web thickness alone.

The girders are spaced at 16 ft. 9 in. centres and the cross-girders are 21 in. × 68-lb. wide-flange beams at 3-ft. spacings. To facilitate the dismantling and re-erection of this bridge — to meet possible variation in traffic conditions — the cross-girders are connected to the main girders by 3 in. × 3 in. × $^3/_8$ in. angles instead of their being directly welded together; the latter practice would have saved 2 tons in weight of steel used. Every third cross-girder is also connected both to the upper parts of the main-girder web and to the top flange by tapering knee-brackets which also act as rigid girder stiffeners, each bracket having a $^1/_2$-in. web and a $^3/_8$-in. flange plate.

Welding.

The welding was mainly $^3/_{16}$-in. — $^1/_2$-in. filet welds, but double grooved welds also were used to connect the web and flange splices in the girders. Only qualified welders, who had passed tests consisting of welding test-specimens subsequently tested to destruction, were allowed to carry out the welding on this bridge. Mild steel electrodes with a covering of low hydrogen type were used throughout.

The total weight of this all-welded superstructure is a little under 114 long tons, a saving of 15 % over the weight of a similar riveted job. It is also considered that lack of rivets and of vertical stiffeners outside the girders greatly improves the appearance of this bridge as seen from the important highway it spans.

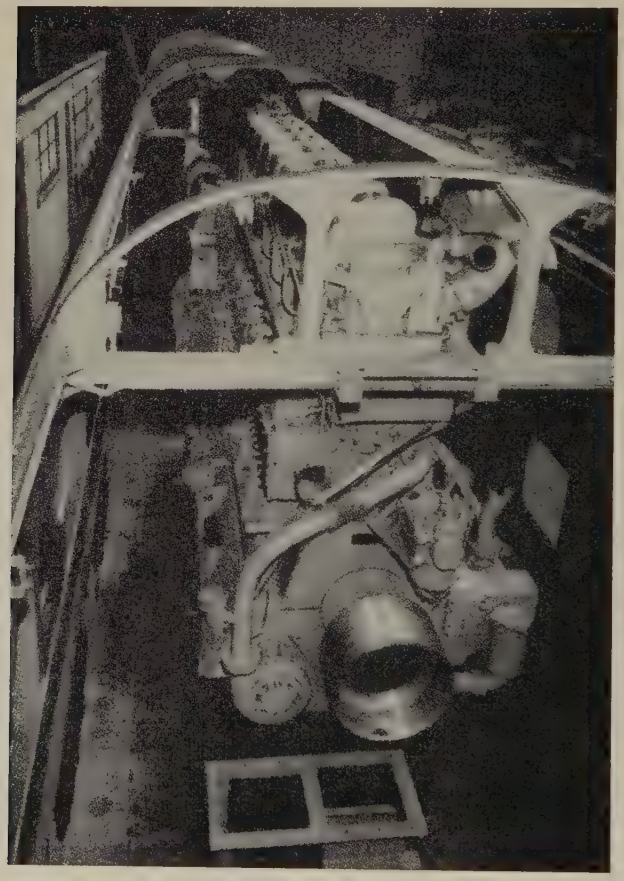
This bridge was designed by Mr. C. F. Blanchard, Deputy Chief Engineer (Bridges), New York State Department of Public Works, and approved by the D. & H. RR. administration. Construction was also carried out by the State, a railway inspector being on the job.

[621 .431 .72]

Framing of a locomotive body.

The principles of construction adopted for a large main-line locomotive of which the weight was limited.

(*Diesel Railway Traction*, February, 1956.



The frame structure, showing transverse and cantrail members, with the 25-ton engine-generator group in position on four-point semi-elastic supports.

To build a Diesel-electric locomotive of 1 750 B.H.P. incorporating an engine running at only 625 r.p.m. on a Bo-Bo wheel arrangement with an axle load of 21 tons necessitates careful design of the mechanical portion, so that the maximum possible proportion of the material embodied should take adequate share in the stress bearing.

The use of an integral body and under-

frame structure with all members sharing in the load carrying has been practised for many years in railcars, but is not so well known in locomotive design. Yet the question became one of the vital factors

1955, but a few further words may be said now about the body structure.

In considering the construction of an integral body and underframe differing from the more normal separate construc-

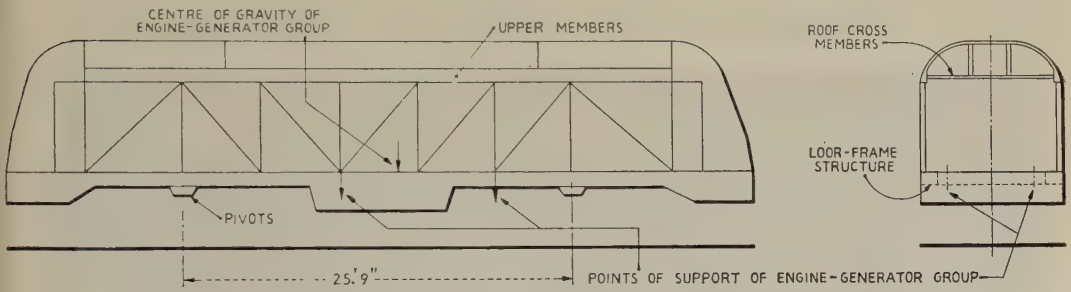
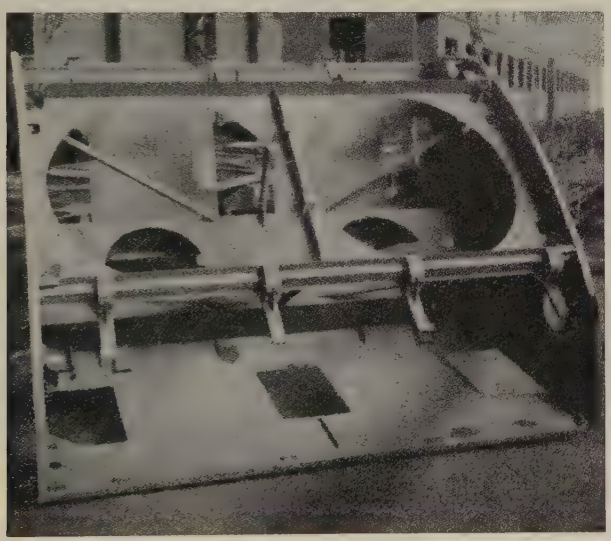


Diagram of 50-ft. integral welded steel frame for 84-ton Bo-Bo Diesel locomotive.



The welded steel structure forming the compartment housing one of the radiator banks in the roof.

to the S. A. John Cockerill (now the S. A. Cockerill-Ougrée) when it received an order from the Belgian National Railways for 55 locomotives of the proportions mentioned above. These locomotives were described at length in our issue of April,

tion of heavy underframe of rolled sections, the use of light alloys or high-grade alloy steels is sometimes reviewed; but these materials do not give any increase in rigidity compared with normal steels, and this would be a leading desideratum

if their more expensive cost was to be justified. The problem in the design of these S. N. C. F. B. locomotives seemed to be to make the best possible use by good design of ordinary steels.

Basic features of design.

In principles of design the decision was made to have two strong side beams bottom by strong cross bracing, so that the whole structure would be in the shape of a box strongly resistant to torsion and bending. There would be no stress-bearing roof structure in the railcar-frame sense.

The design of this chassis-superstructure, like that of the whole locomotive, was worked out in the Cockerill plant at Seraing, with collaboration of the

The body framing of the S. N. C. F. B. 1 750-B.H.P. locomotive before installation of the equipment.

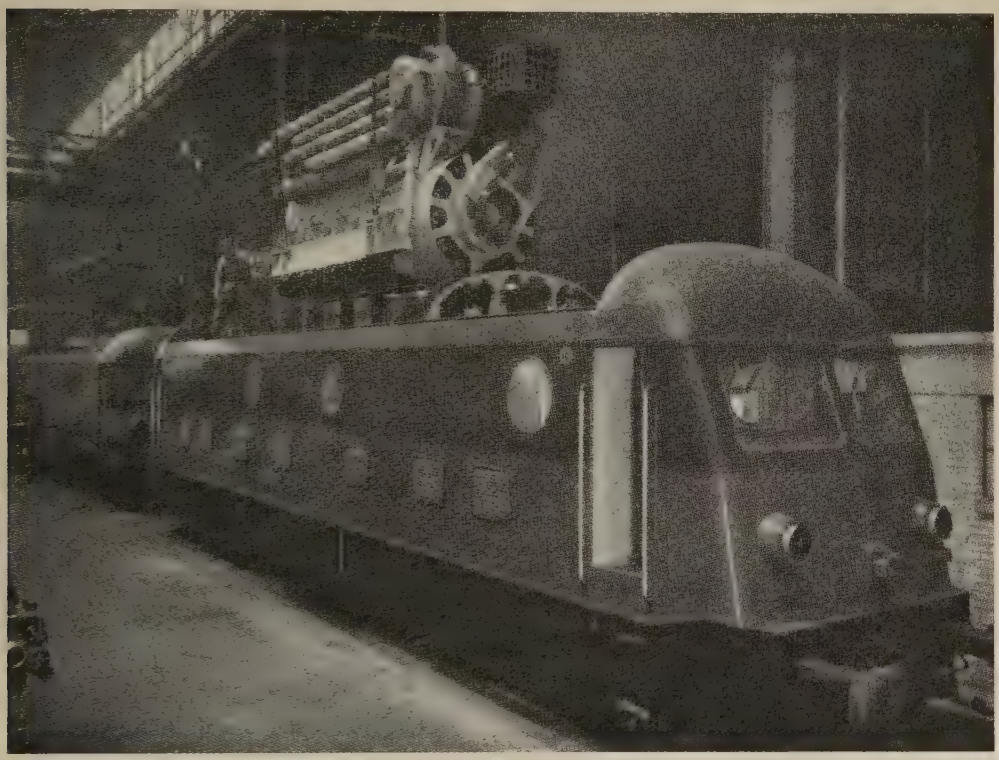
of trellis construction each completely welded up as a monobloc, with thin panel plates, and each forming a wall about 6 ft. 6 in. deep and extending between the two driving cabs, and of which the vertical moment of inertia would be considerable in relation to the weight. These two beams, in which, under load, all the verticals would be in compression and all the diagonals in tension, were to be tied together top and

Baldwin Locomotive Works; but the actual construction and methods of erection and assembly were done by Baume & Marpent and Les Ateliers Métallurgiques, Nivelles, as sub-contractors to Cockerill.

General lines of the framing are shown in the accompanying diagram. At floor level are two continuous side box-shaped members, fully welded and almost 50 ft. long as they extend over the whole loco-

motive length. These two beams form the principal longitudinals and are the bottom members of the whole framework. They are of A37SC steel, and transmit to the transverse frame members at the same level the static vertical loads not directly applied to those members. They bers at the bogie pivot points, and by the central main fuel tank structure, the whole being welded up as one piece.

The upper longitudinal beam of each side frame is also of box section. The roof members are attached to these top longitudinals through the intermediary



Lowering the 1 750-B.H.P. Cockerill-Baldwin engine and attached main generator into the integral framework of the Bo-Bo locomotive. The welded Vierendeel girder cross members at roof level can be seen; and also the length of the trellis frames between the two cab structures.

take up a great part of the traction stresses, and almost all the buffing loads; and deflection under any of these shock loads is prevented by the strengthening effect of the trellis members, to which they are welded. These lower longitudinals are tied together transversely by the drag-box structures, the cross members of rubber strips. The side panel plates are riveted to the top longitudinals and also to the bottom pair.

Vertical and diagonal members of the side frames are pressed sections and profiles of A42SC steel; and the outer panel plates are of copper-bearing steel spot-welded to them, with a positioning and

welding sequence specially studied to minimise any deformation of the thin plates. The vertical members of the trellis are spaced at points where there are direct vertical loads, such as the weight of the engine-generator group and the weight transmitted through the bogies bearers, as can be seen in the diagram of the framing.

Close attention was given to the welded joints between the vertical and diagonal trellis members and the top and bottom longitudinals to give a strong and rigid joint without any stress-concentration areas; and tensometer measurements made on complete frames under load have shown satisfactory flux lines; and, incidentally, they showed also that the bending, tensile and torsional stresses in the whole framework did not exceed those calculated. One complete frame was also given a fatigue test of 3 500 000 stress cycles without signs of overload.

The side panel plates, besides their supports on the trellis framing, are also well stiffened by small angles to prevent any drumming or vibration of the thin plates. Further, the circular windows and the louvres for the filter panels on these plates are mounted against thin rubber strips, the louvres themselves being on separate panels.

Fuel-tank contribution.

The 4 000-litre (880-gal.) main fuel tank of the locomotive is incorporated in the lower central part of the framework. Because of its depth, its close partitioning to provide surge plates, and the plate thickness, it contributes substantially to the strength of the whole framing midway between the bogie pivot supports. It is so situated that it shares directly in the carrying of the load of the engine-generator group, the rear set of two supports for which — carrying most of the weight — is right above the tank, and the forward sets of supports is between the tank and one of the bogie-centre transverse members. The situation of the engine-generator group is good from the point of view of inertia stresses, and helps to allow easy setting of the engine and its supports, and to give free expansion of the engine bloc both longitudinally and transversely.

Two box-section transversals of forged steel are bolted across the lower portion of the frame at the bogie centre lines and incorporate the pivot pin. This pin and its socket on the bogie bolster take only pivoting and longitudinal forces. They do not transmit the superstructure weight, which is transmitted to the bogie bolster through two sliding side bearers.

At the level of the two main upper longitudinals the cross bracing is at the end by the two cab structures, and, towards the centre, by two Vierendeel girders of A37SC steel, welded up and also welded to the longitudinals so that they are non-removable; but they are so spaced, about 20 ft. apart, that the engine-generator group and other items of equipment can be lifted in an out when sections of the roof plates are removed. Further cross stiffening is given by the profiles incorporated in the end partitions of the machinery room. The whole of the roof plates between the two cabs. can be removed. The two end driving cab structures themselves are completely welded sub-assemblies of pressed double plates, with heat and sound insulating material between the inner and outer walls, and sprayed with an anti-drumming substance.

The engine cooling water radiators are carried elastically in a separate lightweight but rigid welded steel sub-frame or compartment. This sub-assembly slides at roof level between the upper members of the body framing at one end of the engine room; and its weight is carried through rubber supports which help to keep vibrations away from the radiator elements. The radiators are located crosswise in the roof.

[621 .32 (44)]

The standard electric handlamps of the French National Railways,

by M. Varroy,

Ingénieur à la subdivision technique de l'exploitation de la Région de l'Est de la S.N.C.F.

(*Revue Générale des Chemins de fer*, January 1956).

In the February 1955 number, the « Revue Générale des Chemins de fer » announced an important development in the design of handlamps used by the French National Railways (S.N.C.F.), viz. the introduction of electric lamps which, due to the progress in the manufacture of small accumulators, are superior to acetylene lamps, inasmuch as they are more economic and easier to handle, being lighter and smaller.

The note referred to above gave an account of the results obtained at Achères with a particular lamp, specially designed for alkaline accumulators with fixed electrolyte and completely tight, of the SAFT-Voltabloc type.

But it was also stated that other types of accumulators might be used equally well. In fact, non-spilling lead accumulators, with containers made of plastics, have appeared on the market and their use can now be contemplated since the appropriate S.N.C.F. departments have been able to solve, in conjunction with the makers, the difficult problem of automatic charging.

In view of the new perspectives, and in order to avoid and excessive variety of types used, which is always an expensive proposition from a supply and maintenance point of view, S.N.C.F. have studied and constructed prototypes of electric lamps which are able to receive all present and future types of accumulators. These prototypes, numbering 2 000 lamps, have now been taken into service, mass production being subject to a trial period of adequate length.

In the following, it is intended to give some information :

— about the lead accumulators and their charging sets, and

— about the lamps themselves which are « universal » in two senses inasmuch as they can be fed by all the different types of accumulators or even by batteries, and can be used by staff of all departments : shunters, train staff, examiners, permanent way staff, etc.

These lamps, designed by S.N.C.F., have been specially studied with a view to meeting precisely the requirements of the different departments.

* * *

LEAD ACCUMULATORS AND THEIR CHARGING SETS.

The lead accumulator is older than the alkaline accumulator of the Voltabloc type. But if it has certain minor drawbacks such as, e.g., the need for a periodical check of the water filling, and shorter life, it is on the other hand on balance less costly since the first costs of the accumulators of the two types are in a proportion of the order of one to four. Moreover, the lead accumulator need not be hooped in the same way as the completely tight accumulators which must withstand internal pressures arising during the charging.

The trial carried out will also permit a better appreciation of the respective features of the two types of accumulators.

However that may be, if the lead accumulators can now be used for handlamps, this

is due to the marked development which has taken place in recent years. Thus, the manufacture of highly shock-resistant containers of plastics (polystyrene) and the use of balsa separators which, within a small space, store a great quantity of electrolyte without neutralising the diffusion, have permitted the production of small lead accumulators which are practically non-spilling.

The makers have thus succeeded in producing 4 V accumulators of acceptable weight.

If the accumulators are non-spilling, they are nevertheless not tight, and must not be tight because of the need to evacuate the gases during the charging. But these gases are liable to attack the cases in which the accumulators are enclosed. In order to avoid any such contingency, the accumulators have been fitted with vent-holes through which the gases are evacuated.

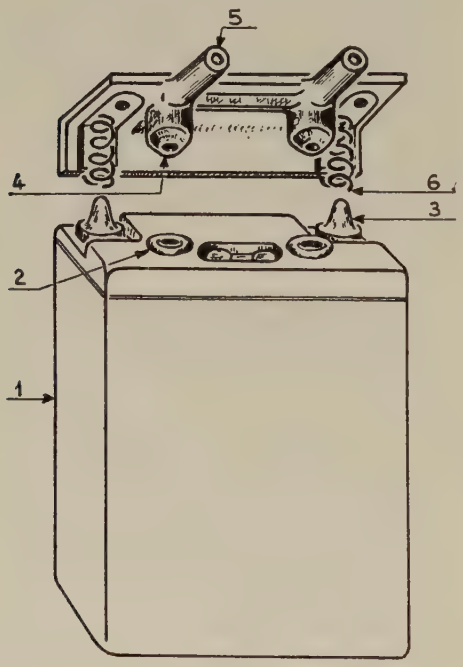


Fig. 1. — Accumulator and connecting box.

1. Container of transparent shock-resistant polystyrene.
2. Gas outlet orifice with neoprene joint.
3. Conical contact terminal.
4. Tube with spherical contact.
5. Gas outlet duct.
6. Contact spring of stainless steel.

The device used, which is shown in figure 1, consists of a cast piece of polyethylene fixed to the central wall of the lamp by means of two screws which have, at the same time, the function of ensurring the continuity of the electric circuits.

It comprises two small ducts. Two of their ends communicate with the free air, the others terminate in two bosses which match exactly the shape of the accumulator orifices.

There are also two contact springs which dovetail with the conical terminals of the battery in such a way that bulb and charging set are, on being connected up, linked to the energy supply by mere contact pressure. There is thus no need for electric wires and for connections made by hand.

As the springs are made of stainless steel and the accumulator terminals of non-deteriorating or chromiumplated metal, lasting contact is guaranteed.

Moreover, the accumulator terminals are placed eccentrically so that they can only make contact in the position which corresponds to the required polarity.

Finally, being made of shock-proof polystyrene, container and lid offer a very high mechanical resistance.

* * *

CHARGING SETS.

The problem which had to be solved presented numerous difficulties.

On the one hand, it was necessary to design chargers which can be adapted, by a simple adjustment, to the different types of lead accumulators in use (Fulmen, Tem, Oldham) whose internal resistance differs because of their different characteristics.

On the other hand, the S.N.C.F. had to insist that, the accumulators, in order to be serviceable during the winter when the nights are long, must be able to last for 16 hours, and that their charging must be

completed in 8 hours. Moreover, it was stipulated that the charging should take place without any supervision and, in particular, that the chargers, whilst ensuring a complete charge in 8 hours, should permit a very long use under voltage without the risk of the plates deteriorating through a prolonged charge, or the effects of electrolysis or boiling having an influence on the invervals at which the electrolyte should be checked.

around the electrolysis voltage. These relays serve to modify the current by means of appropriate resistances (fig. 2).

The charging current intensities have been determined in such a way that the greatest number of ampere-hours C 1 are restored to the accumulator in the shortest possible time T so that in the second phase, the energy C — C 1 is supplied during the time T' = 8 — T.

In the circumstances, current I_1 is

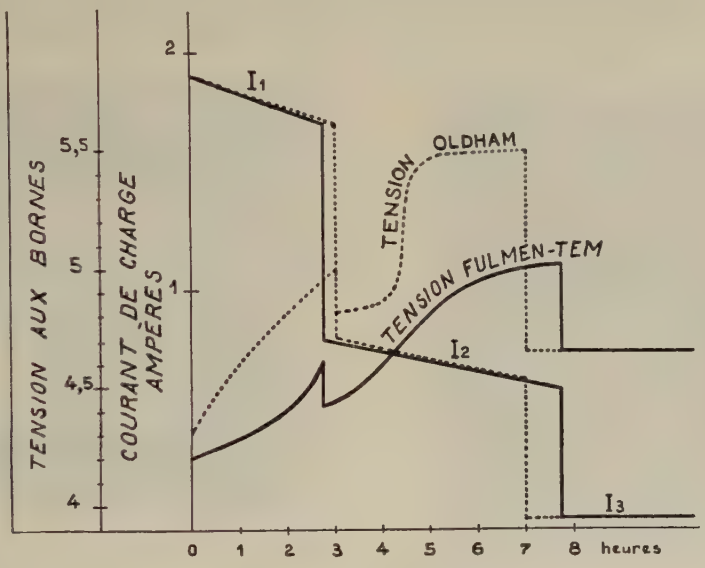


Fig. 2. — Charging characteristics.

Tension aux bornes = terminal voltage.— Courant de charge = charging current.— Heures = hours.

These conditions were almost « Draconian » since the normal charging period of accumulators is longer than the discharging period. They have led to the adoption of a three-phase charging procedure, charging:

— maximum current during the first phase;
— medium-strong current during the second phase;
— a very weak current during the third phase.

These successive phases are ensured by means of two voltmetric relays, adjusted

of the order of 1.8 amps, and the current of the second phase $I_2 = \frac{C - C1}{T'}$ assumes such a value that the voltage curve is of the same shape as that obtained by a normal ten-hour charge.

Finally, after eight hours, when the whole energy C has been restored, the action of a relay reduces the current I_3 to a value of 0.040 amps which keeps the accumulator in working order even if it is not going to be used for a long time.

The charging sets are small in size and consist of individual wall-mounted units.

They are designed to work with supply voltages of 110 or 220 V. To the bottom of each of them are fitted a hook and a flex wire with plug which ensures the electric connection with the lamp when the latter is suspended on the hook.

The charging is indicated by a red pilot light. The end of the charging operation is indicated by the extinction of the red light and the appearance of a green light.

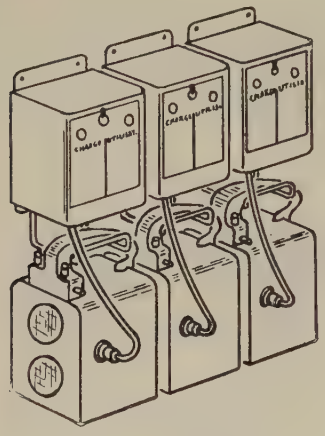


Fig. 3. — Charging sets.

From this moment, the lamp is ready for use and can be handed over to the staff. Figure 3 shows how the charging sets will be installed.

* * *

LAMPS

To begin with, the S.N.C.F. departments designed a special prototype of lamp for wagon checkers which would enable them to carry out their wagon checking without any hindrance.

In order to enable the operator to make full use of his hands, this small-size lamp is carried over the shoulder by means of an adjustable strap.

This lamp (fig. 4) is fitted with optics permitting at the same time the reading, in a vertical plane, of the wagon labels and, in a horizontal plane, of the train indication.

The bulb is fed by a small lead accumulator of 5 ampere-hours capacity, consisting of two series connected elements of 2 V.

The lighting obtained at reading level is of the order of 50 lux at one metre distance.

This lighting can be obtained for an uninterrupted period of about 10 hours.

Finally, the rear wall of the lamp carries a recessed light switch, a fuse protecting the circuits, and the current intake.

Fig. 4. — Lamp for wagon checkers.

The use of this lamp is limited to a well defined category of staff. But the main study, made with a view to designing a lamp for the great majority of staff for all departments, has led to the design of a handlamp carrying, in the rear, an accumulator casing and, in front, the optical parts.

As already mentioned, the cases studied for the purpose are designed to receive different types of accumulators or even batteries for work where the lamps are used for relatively short periods at a time (e.g. at certain minor stations).

Their design has been studied with a view to reducing the number of different parts to be manufactured. The aim has

been to make the different parts as accessible as possible and to permit dismantling without the use of special tools so that replacements or periodic inspections can be carried out with the least possible delay.

The framework, though made of light metal (aluminium sheet), is able to sustain normal shocks.

The lamp as at present designed still calls for the use of usual manufacturing methods but the cases have been designed to permit, in due course, the application of new techniques in respect of plastic materials. The use of new materials can, however, only be contemplated if the lamps are produced in large numbers so that the fairly high cost of the mould can be written off.

The handle, which is of large size, is made of shock-resistant polystyrene.

The lower part of the lamp can be removed so that the accumulator can be very quickly inserted or removed.

Protection is afforded by an easily accessible fuse which protects the charging circuit as well as the lighting circuit.

The current intake is of the co-axial type, the positive pole being insulated and the negative pole connected to the mass.

The connection of the flex with the plug is reinforced by a polyethylene moulding which cannot be wrenched off.

These lamps provide satisfactory individual lighting and can also be used for colour-light hand signals : red for stop, green for departure.

For this purpose, two different prototypes have been produced which use the same case already described, viz. :

— lamps with single optics of large size, where the colour aspect can be changed mechanically, and

— lamps with several smaller optics with electrical control.

The control devices have been thoroughly studied as it is absolutely necessary that shunting staff riding on the footboards of wagons should be able to change the colour aspect without having to use both hands.

Lamp with single optics and mechanical operation.

This lamp (fig. 5) is mainly designed for shunters, examiners, and train staff and permits the display of a red light. This is obtained by the simple operation of a push-button placed close to the handle and well within reach of the hand.

The control device, illustrated in figure 6 below, is very simple.

Fig. 5. — Lamp with one set of optics.

When operated by the push-button, the pawl of the operating rod causes the frame of the screen to turn round and come to lie in the ring-shaped space between the two reflectors.

Having reached the end of its travel, the pawl is trapped in a slot where it is held by a spring.

To extinguish the colour light it is sufficient to operate the handle fitted to the button. A slight turning movement of this handle will free the pawl.

The device is fixed to the lamp by means of a single screw. It can be replaced or repaired without difficulty and without loss of time.

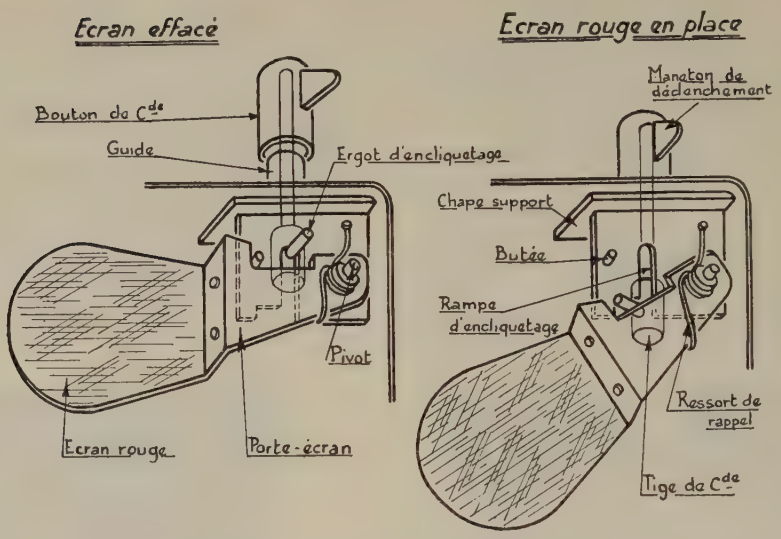


Fig. 6. — Device for displaying red colour light signal.

Écran effacé = screen turned off. — Écran rouge en place = red screen in position. — Bouton de commande = operating knob — Ecran rouge = red screen. — Porte-écran = screen holder.— Ergot d'encliquetage = pawl. — Maneton de déclenchement = release handle. — Chape support = supporting cover. — Butée = stop. — Tige de commande = operating rod. — Ressort de rappel = drawback spring.

Reflectors.

The reflectors are made of aluminium sheeting subjected to anodic oxidation. They are so thick that there is no risk of the curves being distorted when the lamp is cleaned.

The set of optics consists of an intensive bottom reflector which ensures excellent long-range visibility of the red colour light signal, and a front reflector with large aperture (83 millimetres) and great diffusion which represents a veritable light fitting.

The divergence is very great and permits a wide range of perception when the lamp is moved or displayed on curved track.

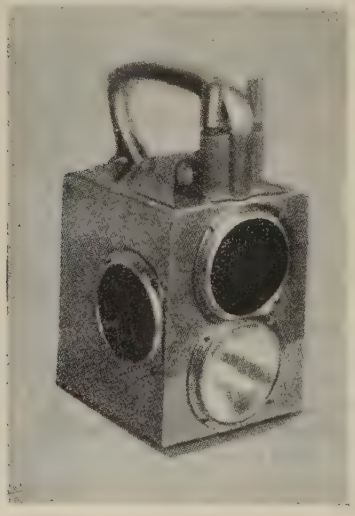


Fig. 7. — Lamp with three optics.

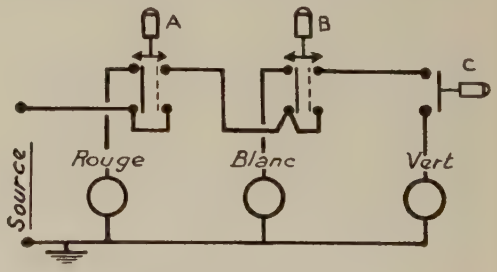


Fig. 8. — Connection diagram for colour lights.
Rouge = red. — Blanc = white. — Vert = green.

The lamps are fitted with bulbs of 4 V, 0.5 or 0.8 amp. their luminous power with 0.5 amp. bulbs being as follows :

Divergence	Candle-power
axial :	300
2.5°	210
5°	90
10°	20
15°	11

Lamp with three optics, electrically selected.

This lamp (fig. 7) could also be used by staff of all departments but it has been specially designed for station staff concerned with the despatch of trains. It permits the display not only of a red light but also of a green light.

This lamp carries three optics with an aperture of 60 instead of 83 millimetres. The transition from one to the other is effected by two appropriate switches.

By combining these two switches, it is possible to obtain separately the red light by pressing-button A, the white light by pressing-button B, as well as the repeated transition from white to red light and vice versa by the repeated operation of button A (fig. 8).

The green light which, at night, serves as a departure signal for the train, can only be displayed if the white and red lights have previously been extinguished.

When this condition is fulfilled, the green light, arranged in a side wall of the lamp, is lit by the operation of button C, fitted to the side of the handle.

The position of this button is specially designed so that the display of the green light to the enginemen must be the result of a deliberate action.

* * *

CONCLUSIONS.

The 2 000 electric lamps which have been taken into service will be subjected to thorough trials which will show, in practical operation over a fairly long period, whether the new lamps have in fact all the advantages of easy handling and long life expected from them.

It may be expected that the operating staff will appreciate their light weight, their handiness and their cleanliness.

It may also be expected that the pratice will confirm the results of laboratory observations as regards the behaviour and efficiency of the accumulators and charging sets as well as the cost price of portable electric lighting which should be more economic than acetylene.

Moreover, owing to the possibility of using any source of electricity (accumulators of different makes, batteries), a field of competition is opened up which promises success from a technical as well as economic point of view. The trials will incidentally be extended to all types of accumulators which appear on the market.

[621 .431 .72 (42)]

Two-car sets commissioned by B.R.

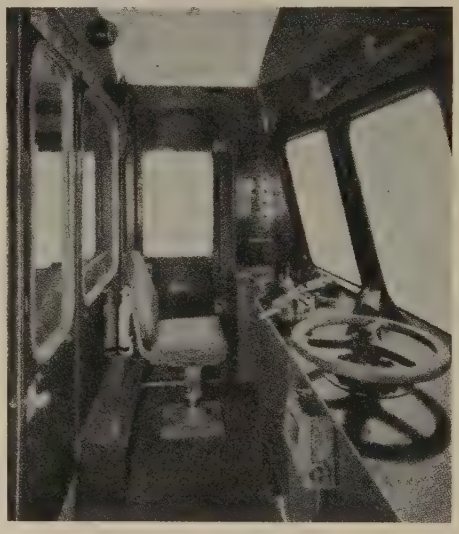
Initial results with Metropolitan-Cammell units show 200 % passenger increase.

(*The Oil Engine and Gas Turbine*, March-April-May, 1956.)

By the end of the 15-year period of British Railways Modernization Plan it is expected that some 4 600 railcars with oil engines will be at work. Those so far put to work have attracted additional passengers — nearly 200 % in the case of the first few days of the Bury-Bacup service inaugurated only so recently as February 6. Seven new two-car sets give 35 trains a day in each direction, as compared with 19 formerly; further, they will replace steam trains on nine of the regular runs in each direction daily between Manchester Victoria and Bury, plus two regular steam services between Rochdale and Bury.

So far British Railways Plan includes orders for 411 Diesel railcars to be manufactured by Metropolitan-Cammell Carriage and Wagon Co., Ltd., of Saltley, Birmingham. They are of varying types, enabling train units of different lengths to be marshalled together to suit particular services. They will be delivered in two-, three-, four- and six-car units. The first order now being delivered and here described involves 36 twin units, seven for the Bury-Bacup service on the London Midland Region already mentioned, and 29 sets for East Anglia on the Eastern Region — each twin unit comprising one power car and one driving trailer, with identical driving compartments at the outer ends enabling operation in either direction.

Overall dimensions and seating layouts are similar to those of the twin units being built by the British Transport Commission at Derby, but advantage has been taken of the Commission's policy to allow Metro-Cammell a free hand in design within the limitations of normal regulations and gauge restrictions. Dimensions of each vehicle are as follows : Length over buffer faces, 60 ft. 8 in.; length over headstocks, 57 ft.; bogie centres, 40 ft.; bogie wheelbase, 8 ft. 6 in.; diameter of wheels, 3 ft.; width over body panels, 9 ft.; overall width, 9 ft. 3 in.; height from rail to top of roof panel, 12 ft. 4 ½ in.



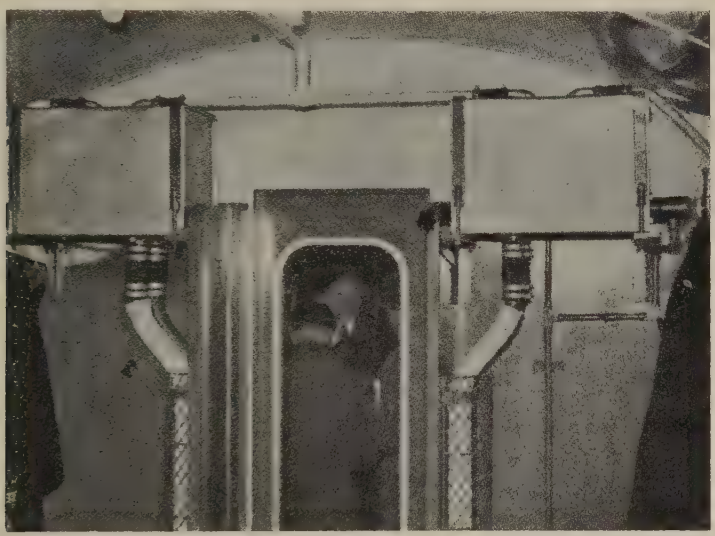
Interior of the full-width driving cab, one of which is provided in each powered and trailer car.

In the power cars a combined luggage and guard's compartment is provided and

in the driving trailer there is a toilet compartment situated at the trailing end, with access through the guard's compartment from the power cars. Details of the layouts of the two designs are given in elevation and plan views in these pages. Bury-Bacup sets carry 12 first-class and 105 third-class passengers, whereas East Anglia sets carry 128 third-class passengers and no « firsts ».

speed Wilson-type epicyclic gearbox. Thence a propeller shaft is coupled to a final drive mounted on the inner axle of the driving bogie. This final drive incorporates the forward-and-reverse mechanism.

The cooling fan for each radiator is driven from a bevel mounted on the engine, the face of the radiator being in line with the side of the vehicle. A fuel



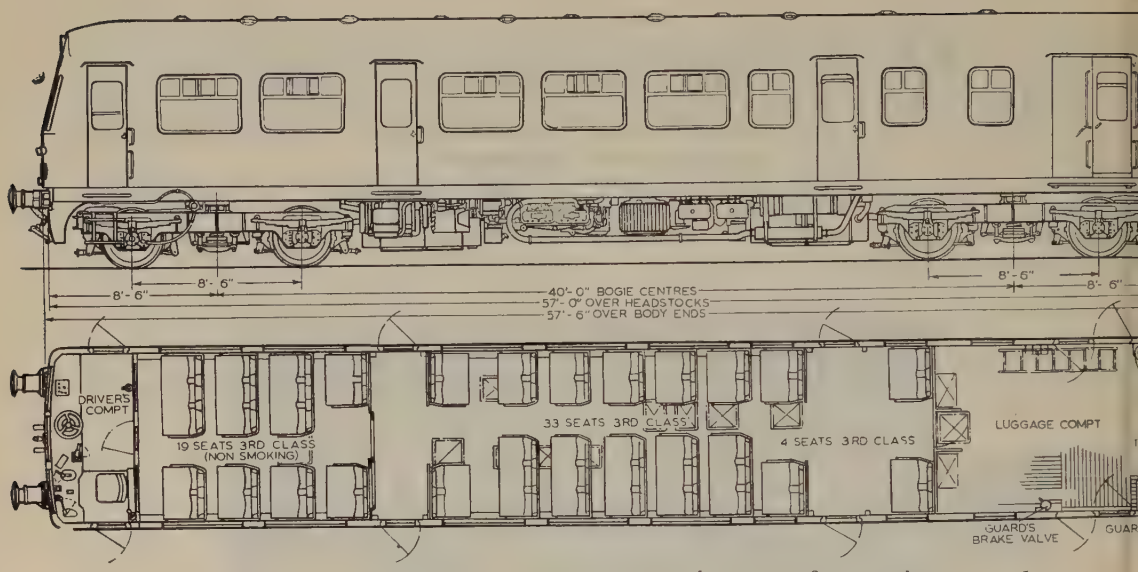
Header tanks for engine cooling systems situated in guard's compartment.

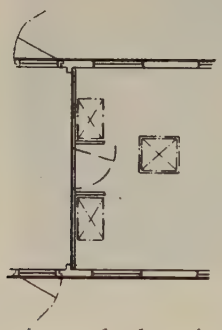
Power equipments, i.e., engines and transmissions, and controls are supplied by the British United Traction, Ltd., of Hanover House, Hanover Square, London, W.1, and are generally similar to those on other British Railways railcars, but incorporating improvements following running experience. The engines, of which there are two per power car, are horizontals of A.E.C. make, having six cylinders of 5.12-in. bore by 5.59-in. stroke (21.3 litres), giving 150 H.P. at 1 800 r.p.m., each driving, through a hydraulic coupling and a short cardan shaft embodying a free wheel, a four-

tank of 80 gallons capacity for each engine is provided in the power car underframe, and one of these has extra capacity to supply the Smiths space heater.

An air compressor of 10-c.f.m. capacity at 1 000 r.p.m. is mounted on and driven directly by each engine to provide energy for the control system, windscreen wipers and horns.

Two rotary exhausters are mounted on each power car, driven by vee belts from pulleys mounted on the input ends of the gearboxes, each having its own oil-air separator. Controls are of the electro-





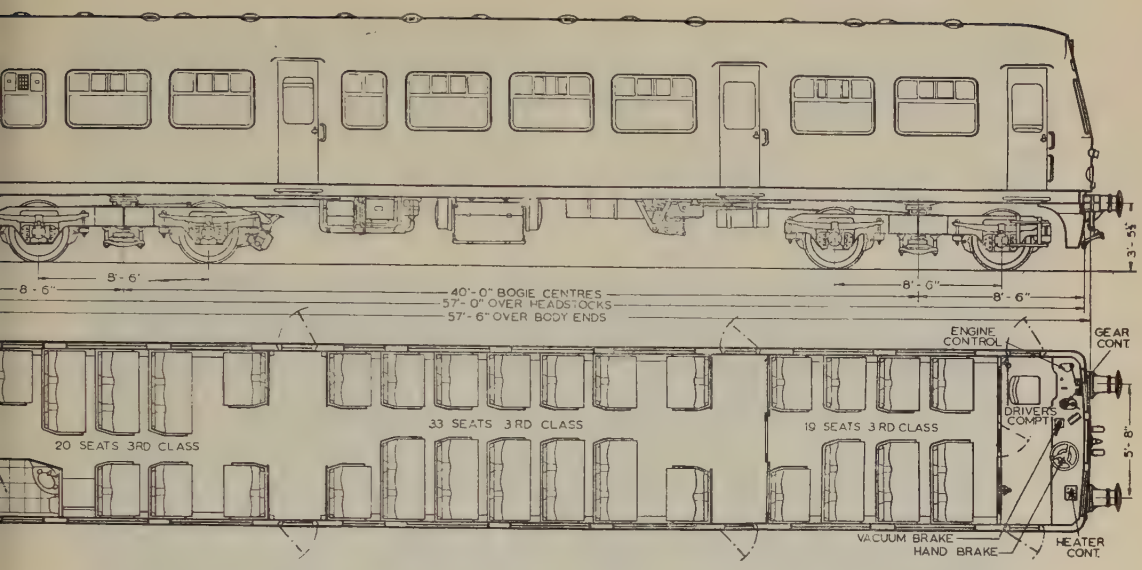
(Above) Elevation and plan views of Metro-Cammel railcars.

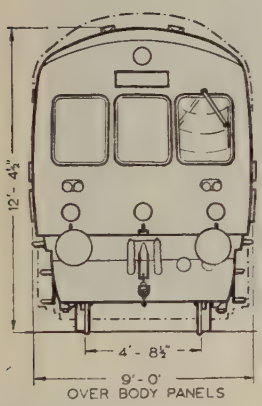
pneumatic type for engines, gearboxes and the forward-and-reverse gears in the final drives.

Fire-protection system of the Graviner type, with spray tubes above and around each engine, is automatic in action and is electrically connected to a bell in the driver's compartment to warn the driver. In addition, separate fire extinguishers are provided in each of the driver's and guard's compartments.

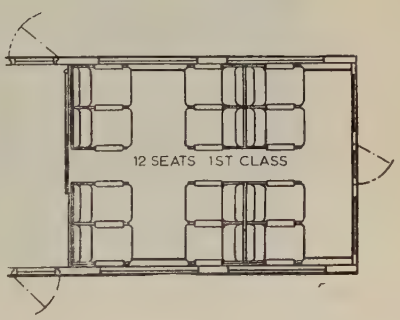
On the power car a Stone's generator of 150-A output is provided, and is driven by four vee belts from a pulley mounted

One of the two-car sets, with trailer on the right; built by the Metropolitan-Cammell organization, these particular cars are for the Bury-Bacup service.





Drawings above and on the facing page show the layout of the 36 twin-car sets. Complete drawings show the East Anglia « all-third » arrangement, whilst inset items at the foot of each page show local alterations to give the Bury-Bacup design (105 third-class, 12 first-class).



on the output end of one of the gearboxes. It is mounted on the frame with a special adjuster for belt stretch, and is controlled by a Tonum regulator. The battery is a NIFE 400-Ah capacity unit, carried in two steel boxes in the frames. The generator on the driving trailer cars is of similar type but of 60-A output, mounted on the inner headstock of one bogie and driven by vee belts from a grooved pulley on the axle. On these cars the battery is a NIFE, 300-Ah capacity.

Bogies for the driving trailer cars are of a conventional type with two brake blocks per wheel, operated by 18-in. standard Gresham and Craven vacuum brake cylinders mounted in the underframe. Driving bogies, also of the four-wheeled type, are designed to accommodate the final drive on the inner axle, and in addition a standard 22-in. vacuum cylinder is mounted in the outer end, thus leaving the whole of the space in the underframe

between the bogies free for the power equipment.

All bogie frames are constructed of fabricated sub-assemblies and roller sections and plates, all riveted together. The bolsters are of the swing type, but anti-sway hydraulic dampers are fitted in the bogies to control and minimize lateral motion of the cars. By this means the bogies are allowed to take a normal action when running but any tendency to swing is quickly but smoothly damped.

Suspension embodies laminated side springs with rubber auxiliaries and nests of coil springs in the bolsters. Wheels are 3-ft. diameter of the solid type, with separate tyres, and the British Timken axleboxes are of the taper-roller-bearing type, fitted with manganese steel liners.

Brake rigging is arranged for combined screw-and-pin adjustment, and standard brake heads with renewable shoes are fitted. The power brake is the Gresham two-pipe, quick-release vacuum system, which uses a high vacuum storage arrangement to obtain rapid release of the brakes irrespective of the exhauster speed, and is similar to the scheme already in operation on British Railways railcars. Emergency application of the brakes can be made from the passenger communication chain pulls over the entrance doorways, or by operation of the « deadman control » when the driver's speed control lever is released; a five-second delay action is provided. Handbrakes are provided in each car, an operating wheel being arranged on the top of each driver's table.

Third-class compartment of the trailer coach, which has toilet facilities.

Layout of the driver's compartment, which is finished in maroon and black to minimize glare and reflection, has been given careful attention. It is commodious, but all controls, instruments, gauges, etc., are arranged to the best advantage. The table to which all these are secured

occupies the full width of the cab, and the handbrake has been embodied in the complete assembly. Removable panels from the table to the floor provide maximum accessibility to all equipment, cables, junction boxes, etc. An air-operated windscreen wiper is fitted to the window immediately in front of the driver, and on the inside a sun-blind is provided. The driving seat is of the adjustable pedestal type, upholstered in hide.

A Stone speed indicator is fitted at each driving end and a mileage counter of the same make is mounted on the axlebox of the leading axle of each power car. Twin warning horns are also provided at each driving end. Marker lights are provided on the ends, and above the central window a route indicator is fitted.

The body structure, embodying novel features in design and construction, is of the integral type. Side framing, chiefly of steel pressings, extends as a complete unit from below the underframe to well into the roof portion and this provides an excellent structure to take care of all superimposed loads. Side panels, also of steel, are spot welded to the structure. Framing members of the central portion of the roof are of aluminium alloy and its outer sheets are of aluminium, with aluminium ventilators riveted thereto. Body ends are of steel, those at the trailing ends having doorway openings to accommodate flexible gangways, whereas those at the leading ends are shaped to give a pleasing appearance and are provided with three windows.

Seats are upholstered in moquette, maroon for third class and midnight blue for first class. Tubular seat framing is used throughout and is finished in maroon, the same colour being used for the lining of the inserts of the aluminium frames and mouldings. Parcel racks, fitted the whole length of the body sides, have aluminium brackets and tubes with netting of suitable shades, and all mouldings, inside window frames, and edgings, are of polished anodized aluminium. Ceiling panels have an « off white » finish and the electric light fittings, together with ventilation grids, provide a pleasing effect; ventilators may be opened or closed only by the B.R. staff.

Steel passenger-entrance doors are interchangeable with those on standard main-line steam stock, and are fitted with full-drop balanced windows. The entrance doors in the drivers' cabs are similar.

Heating of the cars is by warm air through insulated ducting arranged immediately above the floor and secured to the bodysides, with suitably designed apertures below a number of the sets. The warm air is provided by a Smith's combustion air heater fitted below the floor of each car, with the necessary oil tank and filter, etc. Control is from a special switch mounted on the driver's table, the system being fully automatic. The unit may also be used to circulate unheated air on warm days.

As a protection against condensation and noise a layer of asbestos is sprayed on the inside of all the body outer panelling. Underframe members are made up of rolled sections and fabricated units. Each end framing, including headstocks and bolsters, is a completely fabricated unit and other sections are dealt with likewise.

As the Transport Commission specified that the design should be suitable for a 200 % overload the first body shell was loaded with 26 ½ tons of weights representing full equipment and three times the normal seated load. There was no permanent set in the structure when the weights were removed, and later tests with finished cars confirmed this result. All units are jig built to ensure interchangeability and care has been taken in the disposition of body members to the end that required variations in the layouts of the different types of car may be produced from the same jigs. Buffing and drawgear is of a standard type, the buffers being self-contained with rubber springs.

[625 .232 (494)]

New light weight second class coaches,(*)

by R. GUIGNARD,

Ing. dipl., Chef de Section près de la Direction générale des Chemins de fer fédéraux suisses.

(*Bulletin des C. F. F.*, April 1956.)

As a result of the competition for ideas organised in the autumn of 1954 between the manufacturers of railway coaches, the C.F.F. have handed over to a technical co-operative consisting of the Swiss industrial Company, at Neuhausen (SIG), and the Swiss Wagon and Lift Company, S.A., at Schlieren (SWS), the preparation and completion of all the plans for the future standard second class coach. The two firms were therefore essentially responsible for making a synthesis of all the best ideas from the projects sent in for the competition. They have carried out this work in close collaboration with the Traction Department and Shops under the General Management. When the studies were sufficiently advanced, the C.F.F. ordered two prototype coaches from each builder, the first two of which were delivered on the 28th February 1956. These trial coaches are intended, on the one hand, to show the technical and economic advantages of the new type of construction, and on the other, to try out in actual service the innovations adopted in the case of the fittings and equipment.

As the diagram shows, the entry doors of the coach are sited over the bogies. With this arrangement it is possible to get a large passenger compartment in between the two entry platforms; this is divided into two equal parts, one for smokers and the other for non-smokers, by a glass partition with an automatically closing swing door. At the ends of the coach, there is the usual toilet with washbasin, a bench seating two, and the intercommunication doors.

The new coach is one metre longer than the light coach with centre entry doors; this is why it was possible to have two spacious entry platforms and comfortably seat 80 passengers.

The arrangement of the *entry doors* towards the ends of the bogies has certain advantages as far as the passengers are concerned. All the seats are in the central portion of the coach between the bogies, i.e. where conditions as regards comfort and stability are the most favourable. In addition, the toilet is well separated from the passenger compartment, so that there is no smell from it. Finally, the entry platform can be ventilated very efficiently by the opening window near the extra seats.

To facilitate and speed up entering or leaving the coach, the level of the floor of the entry platform has been brought down to 980 mm above rail level. Indeed the first step of the steps is almost at the bottom of the constructional gauge for coaches. The entry door is very simple; it consists of two leaves made up of aluminium alloy sections. A connecting gear co-ordinates the movements of the two leaves. The door has a 720 mm (2.36 ft.) opening, (about 120 mm (4.72 in.) more than in the present second class coaches).

The fittings of the *toilet* have also been improved in order to facilitate assembly and maintenance. The water tanks, in the roof, are well protected from the cold, so that it will probably be possible to have water even in the winter. The outlet pipe from the basin is rectangular throughout its length. It is fitted with a special device intended to prevent as far as possible any

(*) Before June 1956, 3rd class coaches.

fouling of the coupling and drawgear components.

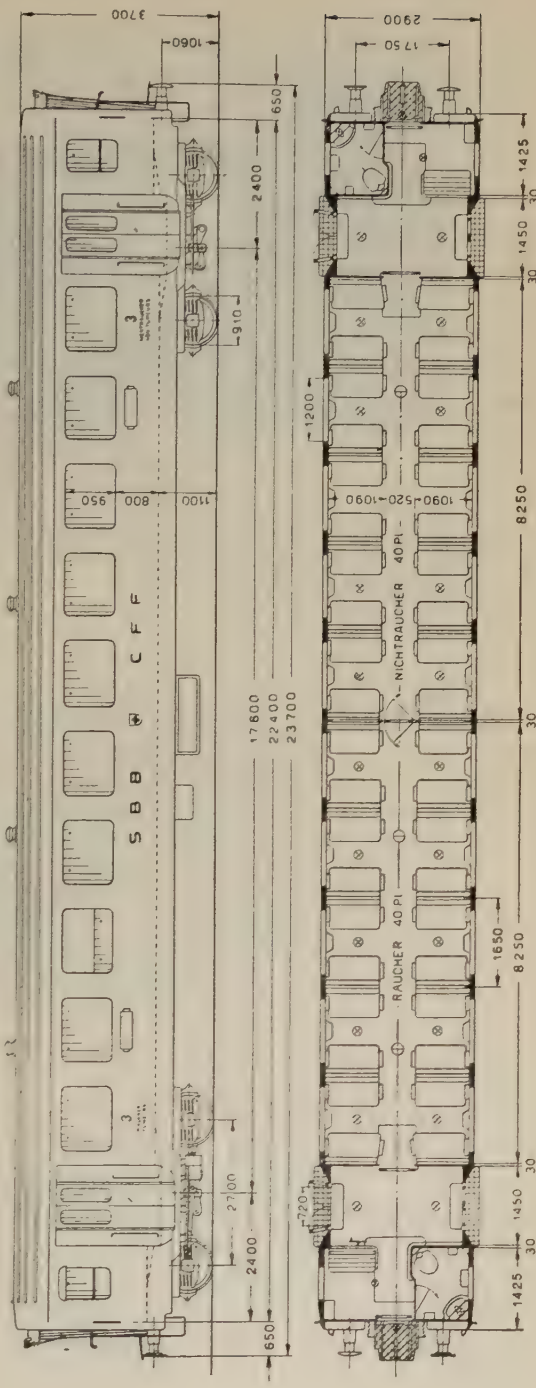
The *intercommunication devices* between two coaches have been improved as far as this is technically possible. The width of opening of the door has been increased by about 80 mm (3.14 in.) compared with present designs. A protective plate fitted with two very practical handrails completes the installations so as to give passengers a feeling of security. Finally, a lamp over the sliding door lights up the passage efficiently.

In the *arrangement of the passenger compartment*, the main objectives have been simplicity, comfort and as restful a colour scheme as possible. The seats and backs are lightly upholstered and covered in brown leathercloth. The construction of the seats and luggage racks has been simplified and made more practical from the maintenance point of view. The second small luggage rack has been suppressed for decorative reasons. The simple and harmonious lines of the seats and luggage racks as a whole give the compartments a spacious and reposeful aspect. Finally, the windows have been made completely draughtproof in the closed position by a new design of the guiding and closing devices. A broken pane can be replaced in a few minutes by an inspector, without any need to dismantle the seats or luggage rack.

The *body of the coach* is a selfsupporting unit made entirely of soft steel sheets with ribs and reinforcements of folded or pressed sheets. Connections between components are made by arc welding.

All the internal surfaces of the body are covered with a layer of insulating material to assure on the one hand protection against corrosion and on the other the thermal and sound insulation. High grade insulating materials of different types have been used as an experiment. Comparative trials are to be made in service to determine which system of insulation is the most effective and the most economical.

To diminish as much as possible the transmission of noise due to running and



Drawing of the new light weight steel 2nd class coach. Tare : 26.6 t; number of seats : 80.

Fig. 1. — Exterior view of the new light weight 2nd class coach.

braking to the body, the interior surface of the frame is also covered with an insulating layer with a bitumastic base.

These new coaches are fitted with the *Oerlikon brake* with two stages of power (brake R) like all the lightweight steel coaches. In order to diminish the transmission of noise due to braking in the passenger compartments, we have suppressed all the rigging that is usually fitted under the frame. Only the pneumatic components of the brake (distributor, tanks and air pipes) are fitted under the frame. Each bogie is fitted with a brake cylinder, an automatic regulator for the rigging and all the usual rigging. The connection between the pipe from the distributor and the brake cylinders is assured by two flexible rubber pipes. For the same reasons as those given above, the hand brake only acts on one bogie. It is fitted in such a way that when it is not on, there is no mechanical connection between the components on the frame and the rigging on the bogie. In this way, the braking efforts develop in each bogie without affecting the body of the coach. Moreover, by this means the rearing up of the bogie under the effects of the braking effort is done away with and consequently one of the causes of flats on the tyres of the wheels. Thanks to these new arrangements, the efficiency of the brake rigging has been increased by about 10 %; measurements taken have shown that it reaches and even exceeds the high value of 90 %. It will no doubt be possible to reduce the total effort on the shoes whilst retaining the usual stopping distances.

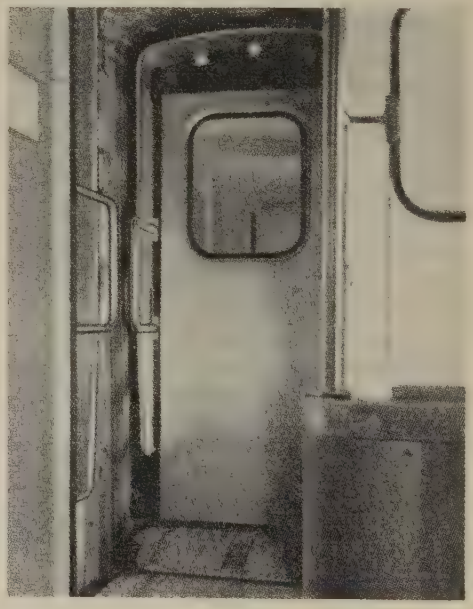


Fig. 2. — Passage from one coach to another.

To enable passengers to benefit by the latest progress in electric heating, we have adopted the *pulsated air heating* system. Each compartment (smoking and non-smoking) has a self-contained installation mounted in the roof, above the entry platform. Fresh air is drawn in from outside through openings above the entry doors by the formation of mist or condensation on the windows and to do away with the currents of cold air round the shoulders of passengers seated near the windows. Each fan has an output of 900 m^3/h, which means that the air is renewed approximately 15 times an hour. In summer fresh filtered air can be circulated through the compart-

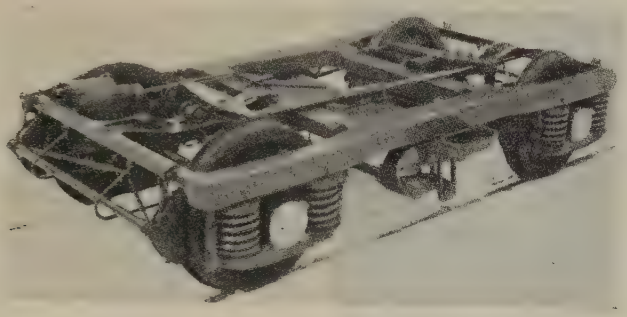


Fig. 3. — SIG bogie with torsion bar suspension.

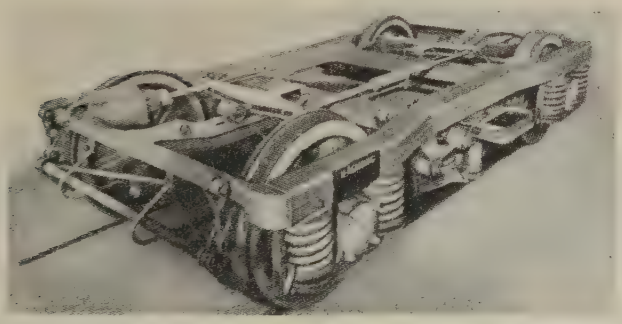


Fig. 4. — SWS bogie with helical suspension springs.

a motor fan unit, then filtered and passed through the electric heater and finally taken through ducts into the compartments. The hot air is circulated through openings under the seats, to avoid draughts round the passengers' legs. Part of the hot air circulating through the main ducts is used to heat slightly the bottom part of the windows and the windowframes. This ingenious innovation is intended to prevent ment at the same rate as hot air. Obviously, the ventilation can only take place when the heating duct is under pressure.

The *bogies and suspension* have certain interesting novel features. The bogie frame is formed of hollow beams made up of pressed sheet components welded together electrically. The axle boxes are fitted with pivoting spherical roller bearings of a new type directly mounted on the journal,

Fig. 5. — Entry door with two leaves.

which has made it possible to reduce the dimensions of the axle box and to simplify the form of the bogie frame. The primary suspension is of the classical type adopted on all light weight steel coaches. Two types of secondary suspension are being tried out. In the SIG bogie, this suspension is by means of two torsion bars of circular section mounted on the bolster perpendicular to the axis of the track. The secondary suspenssion of the SWS bogie consists of four helical springs arranged in pairs at each end of the bolster. Two oil bath telescopic shock absorbers are mounted in parallel with these springs in order to damp out any large scale oscillations. The total weight of the body is carried on oil bath slides at the end of the bolster. The bogie pivot is fitted with a silent bloc allowing the bogie to rotate when running through curves.

To conclude, we would be very glad if all employees who come across these new coaches during their trial period would be good enough to communicate their observations, suggestions or criticisms through the service department. It is intended to order a large series of coaches of this new type during the course of the year.

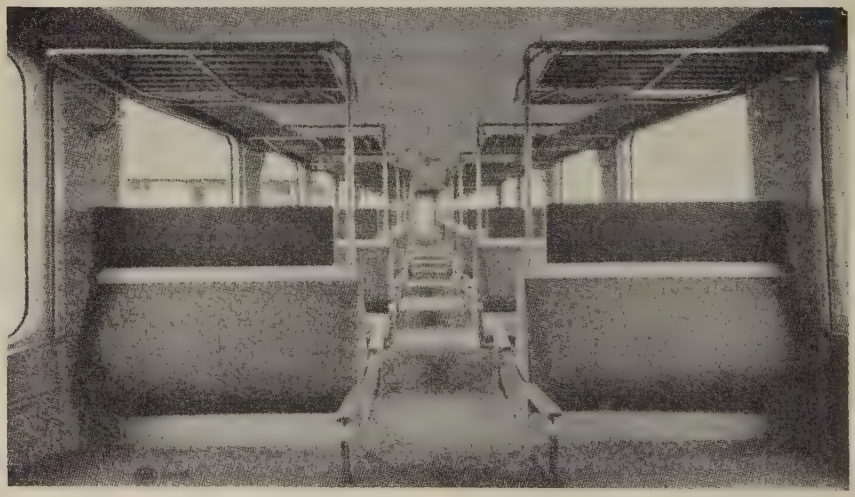


Fig. 6 — Interior view of the compartments.

[625 .212]

Electro-acoustic equipment for detecting flats on the wheels of freight wagons,

by Werner Leitenberger.

(*Signal und Draht*, (*) June 1956).

1. General.

When a freight wagon begins to slide, for example because of too violent a brake application, flats are produced on the wheels which lead to the wagon knocking. Such shocks damage both the track and the wagon itself; they are probably one of the chief causes of broken rails. Consequently, it is advisable to detect wagons having wheels with such flats and take them out of service as quickly as possible. But though it is easy to discover coaches with such flats, this is not the case with wagons on which the men rarely travel. In this case there is no other means of discovering them that the observations of the pointsmen, crossing keepers and other employees when a train passes. However much care is taken in making such observations, they are always indefinite and incomplete. In addition, they only give an approximate idea of the position of the defective wagon, especially in the case of long trains. For this reason, the Deutsche Bundesbahn has had an automatic device for detecting wagons with flats built by Messrs Siemens & Halske, which they have been trying out since the beginning of 1956 at the Carlsruhe-Knielingen Station.

The noise produced by the shock of flats on the wheels of wagons during running is detected in this case by a microphone recording the sonorous vibrations of solids which are transmitted to an indicator equipment. When a flat is detected, a device is unlocked which squirts a jet of a bright coloured paint on the wagon in question.

The equipment must not be too sensitive. Small flats (below 1.5 mm [4/64"] approx). must not be marked, because the regulations in force only provide for the repair of wagons with flats of at least 2 mm (5/64"). It is very difficult to set an exact limit, because with an equal amount of flat, a heavily loaded wagon will produce a more intense shock than an empty wagon. To make quite sure that all the wagons, (even empty ones) are recorded if they have flats of at least 2 mm, it is necessary to be resigned to the fact that heavily loaded wagons with flats of about 1.5 mm will also be marked.

For the pipe to function properly, special attention must be paid to the kind of paint selected. The coloured solution must not settle; it must not be too thick or the pipe will get blocked; it must be clearly visible but easy to remove. In addition, it must not freeze if there is a slight frost.

The problem was not easy to solve, because even when there are no flats, a train in motion already makes a considerable amount of noise, and when passing the microphone each wheel will record a whole combination of sonorous vibrations.

In the preliminary trials therefore only the actual noise produced by the trains in motion were recorded, with and without wagons with flats, by means of different microphones, and the records thus made on the strips were studied in the laboratory. In this way, the characteristic vibrations of flats were discovered and it was found that the problem could in principe be solved.

At the same time it was found that the

(*) Editor : Dr. Arthur Teizlaff - Verlag, Francfort-on-Main.

shock of the wheels on the rail joints might prevent the localization of a flat. The rails in the trial section were therefore welded into a length of 60 m (196' 10 1/4"). It may be pointed out that the trials were made on a section with the old type of superstructure and wooden sleepers.

The equipment consists of a low frequency amplifier, a rectifier stage, an interpretation stage, and a recording stage as well as a power supply from the section. It is housed in a sheet metal case. Its dimensions are approximately 35 × 30 × 20 cm. It is fitted with the following four lamps :

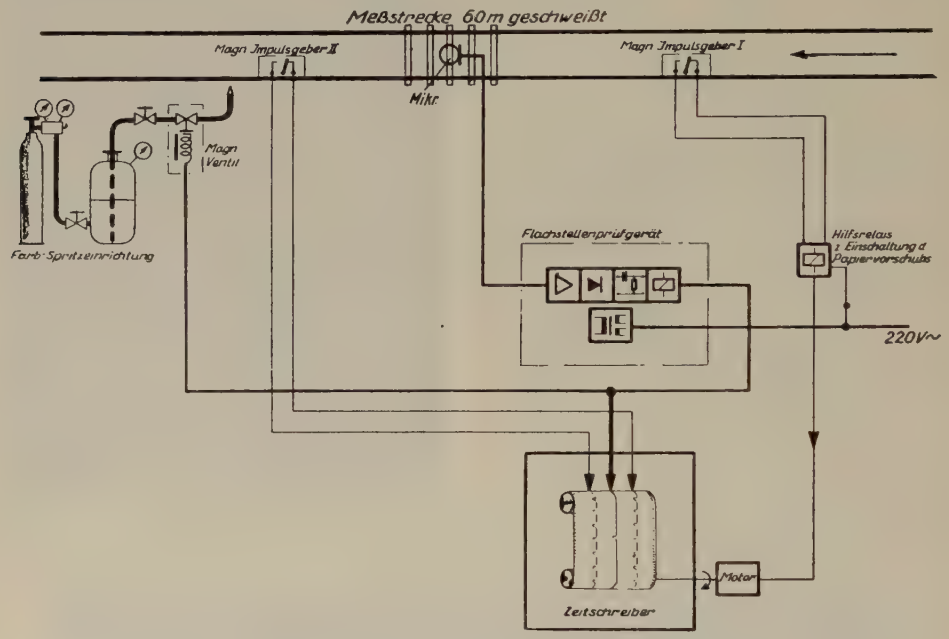


Fig. 1. — Equipment for recording flats. Experimental layout.

N. B. — Messtrecke 60 m geschweisst = 60 m measuring section, welded rails. — Magn. Impulsgeber = Electro-magnetic impulse transmitter. — Mikr = microphone. — Magn. Ventil = electro-magnetic valve. — Farb-Spritzeinrichtung = Paint spraying equipment. — Flachstellenprüfgerät = Equipment for detecting flats. — Hilfsrelais z. Einschaltung d. Papiervorschubs = Auxiliary relay moving on the paper. — Motor = motor. — Zeitschreiber = Chronograph.

2. **Description of the experimental layout.**

The principles of the arrangement adopted are shown in figure 1.

In the middle of the trial section there is a microphone set up on a wooden sleeper and protected by a sheet metal box to detect the noise of the shocks due to flats on the rail. The micro is connected by means of a 200 m (656' 2") long enclosed cable to the actual recording equipment which is in the station building.

2 × 80 CC, 1 × EB 91 and 1 × E 90 CC.

Power consumption is about 60 VA. It is made to work on 110/220 V, 50 Hz. It is so sensitive that it would be possible to detect without difficulty flats of barely 0.5 mm (0.0197 in.). A regulating device incorporated in the equipment enables the sensitivity to be adjusted and consequently to record flats of the desired amplitude. When it is put into work, there is a current impulse of 60 V D.C. from the equipment which operates the recording or colour marking equipment.

The colour marking equipment consists of a reservoir holding about 30 litres, a compressed air cylinder with relief-valve, an electro-magnetic valve, a spray pipe as well as a few auxiliary components (safety valve, pressure gauge, etc.). It is fitted in a pit near the microphone. The paint reservoir is under constant pressure of 4 to 4.5 atm, maintained by the cylinder of compressed air. The jet of paint is freed by the electro-magnetic valve as soon as a flat is detected. It is aimed at the wheel and frame of the wagon (fig. 2).

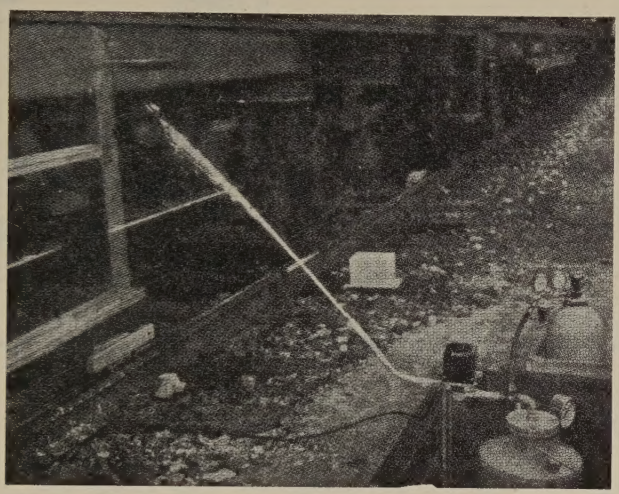


Fig. 2. — Spraying paint on a wagon with a flat.

The noises set up when passing through the recording section are analysed at the interpretation stage in order to determine those due to regular shocks (due to a flat) recorded at regular intervals. When a flat is detected, the electro-magnetic valve of the paint spraying equipment comes into action and the wagon is marked.

The experimental arrangement also includes two transmitters of electro-magnetic impulses and a chronograph. These make it possible to check the accuracy of the information as follows :

As soon as the measuring section is occupied, the impulse transmitter I puts into work through an auxiliary relay, the motor driving the chronograph. The impulse transmitter II records all the axles passing through the measuring section (left and right hand lines of the chronograph). Each flat is characterised by the recorder on the middle line. By counting the axles (left or right hand line) and comparing the middle line, it can be determined which axle has a flat.

3. **Observations and results of trials.**

The first results of the trials have proved satisfactory from all points of view. The equipment has worked almost without failure and does not require much maintenance. In the first nine weeks after it was installed, it only allowed one flat to pass without recording it. During this period, a total of 122 flats were recorded; however, in actual fact such defects were only found on 112 of the wagons marked (i.e. 92 %). The reason for this must be looked for in the fact that the equipment was regulated very sensitively, so as to get the greatest possible number of recordings as quickly as possible. With this degree of sensitivity, the equipment records even very small flats

(0.5 mm) which the inspectors found it very hard to find. Although the number of freight trains running through this station is not very great, Carlsruhe-Knielingen was chosen for the trials because the firm of Siemens & Halske has its equipment and electro-acoustic installations in the neighbourhood.

loudspeaker from the box that a train will arrive on such and such a line with say three flats, so that he can observe the train as soon as it comes.

The final design of the equipment is still to be determined. To avoid the enclosed cable between the microphone and a building, which costs a lot, it would appear

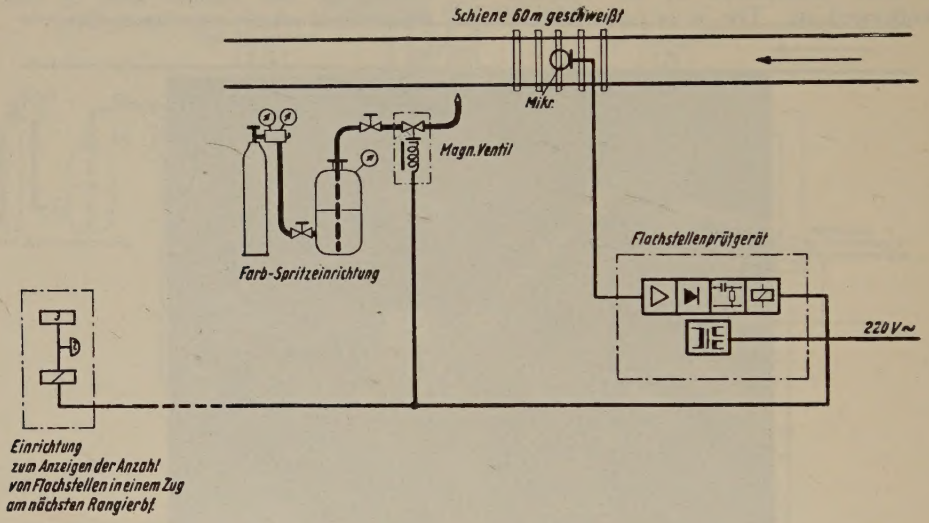


Fig. 3. — Equipment for marking flats. Final arrangement.

N. B. — Einrichtung zum Anzeigen .... = Device reporting the number of flats on a train to the nearest marshalling yard.

4. **Other applications.**

The equipment has now been sufficiently perfected for the trials to continue without the intervention of the maker. It has now been installed, without the chronographical device, according to the arrangement shown in figure 3, on a track where there are a great number of through freight trains in the Frankfort-on-Main region.

The chronograph and the impulse transmitters have been replaced by a simple recording device set up in a junction box which gives an optical indication of the number of flats, at the same time as it works an acoustic signal. This indicator device has to be restored to zero by hand. The inspector, who is generally dealing with some other train, gets an advice by

only rational to put the detection equipment near the microphone. This would then have to be so designed that it would be waterproof and could be fitted below ground level (like the paint spraying equipment in the present case), or else be placed with the paint spraying equipment in a box (for example a telephone box) beside the track.

When siting the equipment, it must be remembered that : within certain limits, the equipment can be adjusted manually to the speed of the trains. It gives the best results between 30 and 50 km (18 and 31 miles)/h. In addition, it trips at high speeds (above 70 km [43 miles]/h) in the case of wagons with four axles. As a result the equipment cannot be fitted at a short distance from a signal, nor on lines run over by fast trains.

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